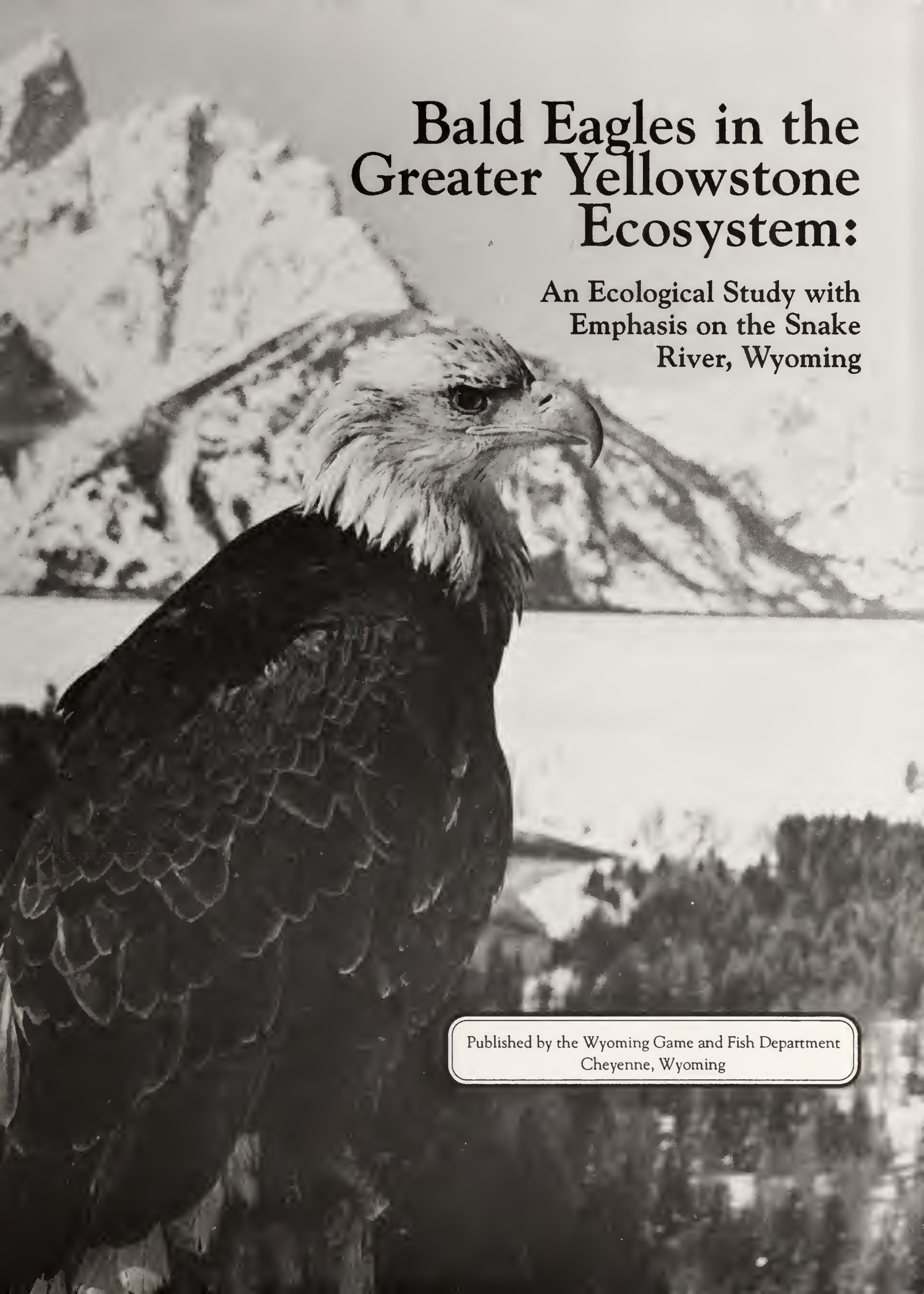

Bald Eagles in the Greater Yellowstone Ecosystem:

An Ecological Study with Emphasis on the Snake River, Wyoming

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Bald Eagles in the Greater Yellowstone Ecosystem: An Ecological Study with Emphasis on the Snake River, Wyoming

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December 1992

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UPB

Frontispiece. The Cabin Creek Male, February 1986. First breeding adult bald eagle captured during study and resident of the most productive breeding area in the Greater Yellowstone Ecosystem. Still on territory in 1992 (Photo by Jeff Rautio and Al Bath).

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EXECUTIVE SUMMARY

Bald eagle (*Haliaeetus leucocephalus*) populations in the Greater Yellowstone Ecosystem (GYE) were monitored by an interagency cooperative effort and nestling eagles also banded between 1978 and 1990. These efforts provided background and direction for more intensive study between 1985 and 1989 to obtain information to improve management of bald eagles. Intensive study focused on movement and habitat use of eagles nesting along the Snake River and Jackson Lake in northwestern Wyoming but also investigated bald eagle ecology througout the GYE.

The nesting population associated with the Snake River, Wyoming increased from 9 pairs occupying 12 breeding areas in 1978 to 21 breeding areas occupied by 21 pairs in 1990. Productivity and nesting phenology are described. A minimum of 193 bald eagles fledged from 171 breeding attempts (1978-90). Throughout the GYE, 288 bald eagles were banded, most (52.8%) in Wyoming. Forty bald eagles were radio-tagged and at least 525 personnel days used to monitor movements and habitat use. Most tracking time (77.8%) was directed at adults associated with 9 breeding areas. Additionly, 4 pairs were visually monitored.

Data obtained by radio tracking, colorband observations and band encounters indicated seasonal movements. Adults nesting along the Snake River, remained in or near breeding areas throughout the winter. Adults that occupied breeding areas associated with Jackson Lake remained in the GYE but wandered extensively during winter. Twenty-one eagles were radio-tagged as nestlings or recently fledged juveniles. Virtually all left the GYE during their first autumn, most migrating to western coastal states, especially Oregon and Washington. Some were observed as far south and west as central and southern California (periphery of the Los Angeles basin). Immature eagles returned to the GYE in spring and remained through autumn. Although found often in natal breeding areas in years subsequent to fledging, extensive wandering by immatures during summer appeared to define the spatial boundaries of the GYE population. Movements within the GYE often covered several hundred kilometers per day and appeared to be responses to temporal and spatial changes in habitat and prey. Conditions and foraging situations exploited by immatures and nonbreeders did not appear utilized by breeding adults. Yellowstone Lake was visited by nearly all radio-tagged immatures regardless of natal origin. Some radio-tagged immatures were detected up to 5 years post-fledging. Two eagles radio-tagged as nestlings were located in 2 successive years in the same wintering areas outside of the GYE and both located in the GYE afterwards. One was located and radio tracked outside of the GYE in western Montana as a breeding adult.

Band encounters and captures indicated age of first breeding tended to be of eagles between 4 and 7 years old. Band encounters, movements of immatures and distribution of an atypical plumage coloration suggest that population increase in the GYE was due to recruitment bald eagles produced along the Snake River. Survival of juvenile (1st yr.) eagles was over 80% and loss of breeding adult males was greater than females. A wide variety of anthropogenic mortality factors were identified. Analysis of blood samples indicate a genetic relationships of GYE bald eagles were similar to those produced in Oregon and Washington.

Home ranges of adult bald eagles associated with 21 breeding areas are described, including data on nesting history, important habitat components and human activity levels. Ten of 21 breeding areas were intensively studied resulting in delineation of high, medium and low use areas, calculation of home range polygons and quantified spatial perch, nest and foraging location relationships. Mean minimum convex polygon area for 11 adult home ranges was 67.19 km^2. Considerable area within polygons was not used by eagles. Including only primary use areas resulted in a mean home range polygon of 47.46 km^2.

A river diversity index (RDI) and lake shoreline diversity index (LDI) were developed using physical parameters to evaluate bald eagle habitat *quality*. An index of habitat *quantity* was calculated by a cumulative effects model (CEM) which measured amount of bald eagle habitat removed by human activity per unit area. An interaction of habitat quality and human activity was readily apparent. Data suggest a threshold of 33% habitat remaining per river mile segment of high quality habitat was minimum tolerated, below which eagle use declined precipitously or was absent. River mile segments with greater than 80% of habitat remaining was used most, somewhat independent of habitat quality. RDI and percent habitat remaining were incorporated in a habitat suitability index (HSI) which was calculated for each river mile segment of the Snake River in Wyoming.

Bald eagle nest site locations provided maximum foraging opportunity at a minimum distance, while avoiding exposure to humans. Small home ranges tended to be associated with high diversity habitats. Large home ranges tended to be associated with low diversity habitat and more habitat removed by human activity. HSI for high and medium use areas were approximately double those for low or no use areas within eagle home ranges. Results indicate eagles selected areas within the home range that provided maximum habitat quality and minimum human disturbance. No relationship was evident between LDI and habitat use by lake nesting eagles. Possible reasons are discussed.

A total of 291 foraging attempts were observed with 126 attempts classified as successful and 107 prey items identified to class. Most (89%) prey items were fish. A distinct bimodal pattern of morning and late afternoon foraging activity was observed. Logit regression analysis of distances between perches occupied immediately previous to foraging (preforaging perch) and foraging location indicated 50% of foraging attempts by eagles associated with the Snake River occurred within 207 m of the preforaging perch while 50% of the foraging attempts on lakes occurred within 594 m of the preforaging perch. Distances between foraging attempts and associated nest were analyzed for individual eagles or pairs studied. Logit regression analysis resulted in high R^2 values and allowed for comparisons among eagles or pairs at the 50% levels. Over 50% of foraging attempts were located within 2 km of the nest for 6 of 11 eagles or pairs studied. Smallest nest to forage distances were calculated for eagles nesting along the Snake River in areas where human activity was not great. Large nest to forage distances occurred for eagles nesting in association with lakes or along the Snake River in areas subjected to high levels of human activity.

Cumulative percent of all perches by distance to most recently active nest for each eagle/eagle pair were plotted. Logit regression analysis of resultant curves of 11 eagles or pairs intensively studied were compared at the 50% level (distance from nest at which 50% of all perches occurred). Perch to nest distances at the 50% level varied from 540 m to 4.4 km. However, 9 of the 11 eagles or pairs had perch to nest distances calculated at less than 2.0 km at the 50% level.

Evidence is presented to illustrate that resident adults temporally and geographically avoided human activity. Circumstances of 126 encounters among resident eagles and humans were recorded. Encounters were analyzed by comparing mean flushing distances, percent of eagles flushing at different distance increments and cumulative percent of eagles flushing at increasing distance from human presence or activity. All analyses indicated eagles were most sensitive to human activity within 200 m. Differences in tolerance to human activity among pairs and in different circumstances are noted and discussed.

Weather severity during incubation and early nesting significantly affected productivity. Productivity also appeared affected by habitat quality and human activity. Highly productive home ranges had 2 to 3 times higher mean HSI values than ranges with low productivity. Baseline data on heavy metal, organochlorine and organophosphate contamination are presented. Lead, mercury and selenium concentrations in blood of bald eagles wintering in the GYE were very high as were mercury and selenium in eagles breeding or produced in the GYE. Contaminant load appeared related to season and prey base. No correlation of contaminant load with productivity was found but contamination may exacerbate productivity problems in breeding areas affected by severe weather.

Research results are compared with nest site management guidelines used in the GYE since 1983. In general, guidelines appeared to be effective without being overly restrictive. Additional management recommendations are provided.

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[1] *Due to sensitive nature of information contained in this volume, distribution was limited.*

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Steve Cain, GTNP, Beth Madden, Terry McEneaney, YNP, Justin Naderman Idaho Fish & Game Dept. and Dennis Flath, MDFWP, reviewed and commented on drafts of this report.

LIST OF ACRONYMS

ACE	Army Corps of Engineers.
AChE	Acetylcholinesterase.
ANOVA	Analysis of Variance.
BLM	United States Bureau of Land Management.
BTNF	Bridger Teton National Forest.
CEM	Percent Habitat Remaining and/or Cumulative Effects Model.
ChE	Cholinesterase.
CI	Continental Idaho portion of the Continental Population Unit, Greater Yellowstone Ecosystem.
CM	Continental Montana portion of the Continental Population Unit, Greater Yellowstone Ecosystem.
CU	Continental Population Unit, Greater Yellowstone Ecosystem.
DDE	1,1,1-trichloro-2,2-bis(*p*-chlorodiphenyl) ethane.
DDT	1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene.
DP	Deep Pools in Snake River.
DR	Deep Runs in Snake River.
EN	Early Nesting season.
EPA	United States Environmental Protection Agency.
ESD	Expert Systems Design.
F	Autumn season (Fall).
GTNP	Grand Teton National Park.
GFAS	Graphic Furnace Additions analysis method.
GYE	Greater Yellowstone Ecosystem.
GYEBEWT	GYE Bald Eagle Working Team.
HCV	Habitat Component Variable.
Hg	Mercury.
HSI	Habitat Suitability Index.
HRDI	Home Range Diversity Index.
IMS	Intermittent Stream Confluence with Snake River.
ISL	Island(s) in the Snake River or Jackson Lake.
ISR	Implied Selection Relationship
LEV	Levees on the Snake River.
LDI	Lake Diversity Index.
LN	Late Nesting season.
LSR	Lower Snake River study area of the Snake Wyoming portion of the Snake Population Unit, Greater Yellowstone Ecosystem.
LSS	Lake Shoreline Segments.
MDFWP	Montana Dept. of Fish, Wildlife & Parks.
MSU	Montana State University.
MO/MR	Moose/Moran Weather Station or area of influence.
NER	National Elk Refuge.
NPS	National Park Service.
NWR	National Wildlife Refuge.
PCB	Polychlorobiphenyl.
Pb	Lead.
PF	Post-fledging season.
PMP	Primary Management Parcel.
PERS	Permanent Stream Confluence with Snake River.
RDI	River Diversity Index.

RIF	Riffles in the Snake River.
RMS	River Mile Segment.
SD	Standard Deviation.
Se	Selenium.
SG	South Gate Weather Station or area of influence.
SI	Snake Idaho portion of the Snake Population Unit, Greater Yellowstone Ecosystem.
SP	South Park study area of the Snake Wyoming portion of the Snake Population Unit, Greater Yellowstone Ecosystem.
SPo	Shallow Pools in Snake River.
SR	Shallow Runs in Snake River.
ST	Snake Teton portion of the Snake Population Unit, Greater Yellowstone Ecosystem.
SU	Snake Population Unit, Greater Yellowstone Ecosystem (includes Snake River in Idaho and Wyoming [i.e. SI, ST and SW].
SW	Snake Wyoming portion of the Snake Population Unit, Greater Yellowstone Ecosystem (includes SP & LSR).
UTM	Universal Transverse Mercator map coordinate system.
USFS	United States Forest Service.
USFWS	United States Fish & Wildlife Service.
USGS	United States Geological Survey.
W	Winter season.
WGFD	Wyoming Game & Fish Dept.
WSI	Weather Severity Index.
YNP	Yellowstone National Park.
YU	Yellowstone Population Unit, Greater Yellowstone Ecosystem.

"The greatness of a nation and its moral progress can be judged by the way its animals are treated."

Mahatma Gandhi

INTRODUCTION

The Greater Yellowstone Ecosystem (GYE) encompasses portions of northwestern Wyoming, southwestern Montana and eastern Idaho (Fig. 1) and contains suitable habitat to support nearly 100 nesting pairs of bald eagles (*Haliaeetus leucocephalus*). Bald eagles nesting in the Wyoming portion of the GYE are especially significant due to past and present reproductive performance. During nationwide population lows of earlier decades, bald eagles of the Wyoming portion of the GYE sustained a reproductive output sufficient for the maintenance of the local population while possibly providing recruits needed for the recovery and maintenance of peripheral populations [GYE Bald Eagle Working Team (GYEBEWT) 1983]. In 1985, breeding bald eagles in northwestern Wyoming outside of Yellowstone National Park (YNP) comprised 48% of total nesting pairs in the GYE but contributed close to 70% of all young produced within the entire ecosystem. Recognizing the importance of this portion of the GYE population, the Wyoming Game and Fish Department (WGFD) contracted on 29 March 1985 with Montana State University (MSU) to study bald eagles in the GYE. The Project Description Summary for the contract outlined the following objectives:

1. Obtain information that will enable site-specific management plans to be prepared for each nest site.

2. Document adult home ranges and winter movements.

3. Determine movements, habitat use and mortality of fledglings, immatures and subadults.

4. Obtain information that will allow for a better understanding of the population dynamics of bald eagles in the GYE.

In order to accomplish these objectives, the following tasks were proposed:

1. Equip nesting adult bald eagles with radio transmitters at 4 to 6 nests.

2. Monitor movements of adults to delineate key use areas and identify important habitat components of nesting territories.

3. At nests where adults will be monitored, equip young with transmitters.

4. Monitor post-fledging movements of young in northwestern Wyoming and identify key use areas and important habitat components.

5. Band all young produced in Wyoming with colored leg bands and US Fish and Wildlife Service (USFWS) serially numbered, pop-rivet aluminum bands.

6. Obtain blood samples from all bald eagles handled during trapping and banding activities and have samples analyzed for environmental contaminants, especially lead (Pb).

These objectives and tasks for research are mandated with high priority in the GYE bald eagle management plan (GYEBEWT 1983) and the Pacific Bald Eagle Recovery Plan (USFWS 1986).

As the study progressed, additional funding and sponsors contributed to the research effort. Study area and objectives were progressively expanded to address the specific needs of additional supporting and interested agencies, eventually including virtually the entire GYE. Additional objectives included assessment of impacts of reconstruction activity of Jackson Lake Safety Dam on the Snake River in Grand Teton National Park (GTNP) and recreational impacts along the Snake River south of Jackson WY on local bald eagle breeding pairs. These objectives were formally addressed through a series of reports (see Appendices) and consultations submitted to responsible resource management and oversight agencies. Data generated during this portion of study also contributed to overall objectives. Effects of human activity on bald eagles throughout the Snake River in Wyoming were also addressed. As a result of changing emphasis in the evolving study, data acquisition and analysis varied among study areas due to differences in contemporary funding levels, habitat, topography, capture success, monitoring intensity or accuracy (influenced by funding level and coincident equipment quality), data analysis schedules and personnel turnover.

STUDY AREA

Specific aspects of natural history that were common among groupings of breeding bald eagles within the GYE were identified by Alt (1980). Nesting phenology, substrate and prey use differed markedly among eagles in specific geographic areas and allowed population units to be delineated. Nesting bald eagles in the GYE were assigned to 3 Population Units: the Snake Unit (SU), Continental Unit (CU) and Yellowstone Unit (YU) (Alt 1980, Swenson et al. 1986). Population Units are shown in Figure 1. Geographic, vegetative and faunal descriptions are contained in Swenson et al. (1986).

The portion of SU in Wyoming was divided into 3 study areas for purposes of reporting results of productivity, adult home range, habitat use and movements analyses of this study. The first area defined included the extreme southeastern portion of Palisades Reservoir in Wyoming and the Snake River upstream to South Park Bridge (Hwy. 26/287), 8 km south of Jackson, Wyoming. This area was designated Lower Snake River (LSR) study area (Fig. 2). The second area included the Snake River and environs from South Park Bridge to the southern border of Grand Teton National Park (GTNP) and was designated South Park (SP) study area. The third area included the Snake River in GTNP upstream, including all of Jackson Lake, the John D. Rockefeller, Jr. Memorial Parkway to YNP. This area was designated Snake Teton (ST). LSR and SP included a 6.4 km wide corridor along the Snake River, 3.2 km perpendicular from the main channel of the river and collectively are synonymous with Snake Wyoming (SW) portion of the SU. ST portion included some areas farther than 3.2 km from the main channel of the Snake River, and a 1 km distance from the shore of Jackson Lake. Collectively, LSR, SP and ST are also referred to as the Snake Unit of Wyoming.

Monitoring immature movements, banding, and contaminant analysis covered virtually the entire ecosystem, including portions of Montana and Idaho. To further define geography in the GYE, additional areas were defined: The Snake River watershed in eastern Idaho from the Wyoming border downstream to Roberts and the mouth of the Henrys Fork River to Ashton was designated Snake Idaho (SI), the Henrys Fork River and associated reservoirs and lakes of eastern Idaho were designated Continental Idaho (CI) and the portion of southwestern Montana within the GYE was designated Continental Montana (CM) (Fig. 1).

METHODS

Selection of Nesting Pairs for Intensive Study

Locations of historical bald eagle nest sites were obtained from WGFD. Virtually all nesting pairs along the Snake River and environs in Wyoming were identified and capture operations initiated for radio-tagging. Additional breeding areas were located as the study progressed. All were included (Fig. 3).

Capture, Handling and Banding

Several methods were employed for capture of specific breeding adult bald eagles. Passive traps, such as padded leg-holds (Harmata 1985) and floating, noosed fish (Frenzel and Anthony 1982, Cain and Hodges 1989) were unsuccessful due to large numbers of nontarget eagle and other species present that eventually fouled most capture sets. Consequently, a radio controlled (Garrot and Hayes 1984), selectively triggered, bownet (Meng 1963) and radio controlled power snare (Hertog 1988) were used exclusively after the first winter (1985-1986).

All bald eagles in hand (captured, banded in nest) were banded with USFWS aluminum bands and plastic or aluminum colorbands, GREEN and white. Between 1980 and 1985, eagles were colorbanded with laminated plastic. Color combination was GREEN with a WHITE midline stripe.

In 1985, color combinations were increased and in 1987 aluminum "pop-rivet" colorbands employed. Color combination and leg banded were determined by GYE Population Unit (GYEBEWT 1983) and geographical area as shown in Table 1. Bands were constructed by ACRAFT Sign & Nameplate Co. Ltd., 10342 59 Ave., Edmonton AB, Canada TGH 1E6. Aluminum colorbands were 3 cm in height and the same color and pattern as those used since 1985. Each was secured with 2, 3 mm "pop-rivets."

Also in 1987, bald eagles captured between the months of November and March and whose affinity to a nest site was uncertain or residency status was "migrant" or unknown were color banded with BLUE and white bands of the same pattern/location relationship as Table 1. Therefore, subsequent sightings of eagles with BLUE and white combinations were known to have been banded within the GYE during winter.

Captured eagles were removed from the trap within 8 min., restrained, hooded with a rufter hood, and processed outside. Eagles were weighed, various morphological characteristics measured and plumage color and condition noted. Data collected were recorded on a Captured Eagle Data Form (Appendix I). All banding, colorbanding, radio-tagging and morphological data were transferred to dBase III+ computer based spreadsheet for subsequent analysis. Gender of eagles was determined from morphological measurements by criteria of Garcelon et al. (1985) and Bortolotti (1984) in addition to behavior at the nest, relative size and position during copulation. Eagles were released within 2 hrs. of capture, within sight of the nest and capture site, but well away from both.

Nestling eagles were banded and radio-tagged in the nest or if nest size and location were too confining or dangerous, eaglets were lowered in a light canvas bag to be processed on the ground. Morphological measurements, plumage condition and other data were recorded for all nestlings on a Nestling Bald Eagle Banding Sheet (Appendix II) but eaglets were not weighed. Prior to leaving the site, most eaglets were hydrated with at least 20 cc of water.

Blood Collection and Analysis

Up to 8 cc of blood were obtained from each eagle in hand using a 22 gauge needle and 10 cc syringe. Blood was drawn from the brachial vein where it traversed the humerus, just proximal to the humero-ulnar joint. Prior to dispensing collected blood into a green top (sodium heparinized) vacutainer, 3 dry smears were made on laboratory slides, immediately fixed with methyl alcohol and stored. Plasma was obtained by separating ½ whole blood volume, centrifuging and pipetting off plasma. Plasma was recovered within 4 hr. of whole blood sample acquisition and both frozen within 6 hrs.

Whole blood was analyzed for 3 heavy metals at MSU Chemical-Analytical Laboratory. Analysis for lead (Pb) was accomplished by digestion with nitric acid and determined by Graphic Furnace Additions (GFAS). Selenium levels were determined by digestion of samples with nitric acid using Palladium Matrix Modifier and GFAS. Mercury was analyzed by digestion of samples by nitric acid in closed vessels and analyzed by Cold Vapor Generation using $SnCl_2$ reductant Atomic Absorption Spectroscopy (Verwolf 1989).

Half of each plasma sample was analyzed for 16 organochlorine pesticide and polychlorobiphenyls (PCB) residues at MSU Chemical Analytical Laboratory. Analysis methods were those recommended by US Environmental Protection Agency (EPA) in Thompson (1974), Section 5, A, (3), (a). Compounds and detection limits are shown in Table 2. The remaining half of each plasma sample was analyzed for total, acetyl and butyryl cholinesterase (ChE) concentrations. Analyses were completed at EPA Environmental Research Laboratory, Corvallis OR.

Dry fixed smears were stained with Giemsa stain and inspected for the presence of hematoza: *Leucocytozoon* spp., *Hemaproteus* spp., *Babesia* spp., *Trypanosoma* spp., and *Plasmodium* spp. Analyses were conducted at MSU Veterinary Research Laboratory.

Radio-tagging

Captured adult eagles were fitted with 54 grm, battery powered transmitters, 13 month life, attached to the central rectrices (Harmata 1984). Tail-mount transmitters reduced impact of auxiliary packages on tagged eagles to absolute minimum. In other studies, bald and golden eagles (*Aquila chrysaetos*) radio-tagged with rectrice (tail-mounted) transmitters behaved normally, copulated, and produced young (Gerrard et al. In Review; Harmata 1984). Adult eagles were also tagged with 100 grm (± 5 grm) solar powered backpack transmitters attached by procedures outlined by Garcelon (1985). Cotton string was employed for suturing backpacks on adults. These sutures deteriorate within 2 years, facilitating shedding of the radio package within 2 years. Some nestling bald eagles were also fitted with solar powered backpack transmitters, and some fledgling eagles with tail mounted transmitters. Stitches of Vetafil^{tm}, a veterinary suture material, were used to connect straps of solar powered backpacks when used on nestling eagles. Vetafil stitches permitted longer retention of backpacks than cotton stitches.

Monitoring Scheme and Tracking Methods

Five tracking seasons were defined on the basis of reported nesting phenology in the GYE (Swenson et al. 1986): Early Nesting (EN) = 1 March - 31 May; Late Nesting (LN) = 1 June - 31 July; Post-fledging (PF) = 1 August - 30 September; Fall (F) = 1 October - 15 November; Winter (W) = 16 November - 28 February. Schedules for monitoring radio-tagged adult eagles were composed by dividing the day (½ hr. prior to sunrise to ½ hr. postsunset) into 4 to 6 hour monitoring periods, number and duration dependent on seasonal day length. Up to 2 tracking periods were randomly selected per day. Number of days each radio-tagged eagle was monitored per week was dependent on number of birds available for tracking, man power and tracking method. Despite attempts to follow random or systematic schedule; political, logistical, financial and biological considerations continually dictated modifications. The overall schedule approached random distribution of monitoring periods but attempts were made to obtain a representative, even distribution of monitoring effort.

Eagles were located by telemetry at the initiation of a tracking bout and visually monitored whenever possible. Triangulated radio locations were used when visual locations were not possible. Triangulation was accomplished by 2 observers. One "roving" tracker with a receiver and 3-element yagi, directional antenna secured bearings of radio-tagged eagles either from a land vehicle or watercraft while moving about. A second tracker employed a dual, 4-element null-peak antenna at a stationary location and continually triangulated location, incorporating bearings received by 2-way hand-held voice transceiver from the roving tracker. Due to the potential of disturbing radio-tagged eagles, no attempts were made to verify triangulated locations not supported by visual locations.

All radio-tagged adult eagles monitored in the LSR were tracked only by single observer with receiver and 3 element yagi antenna. Eagles were located by telemetry at the initiation of a tracking bout and visually tracked whenever possible. Radio locations were used to support observations and were seldom used exclusively for determining the position of an eagle.

Local conditions along the LSR permitted visual tracking the majority of the time. Highway 26 borders the Snake River, mostly within 200 m of the shore from South Park to Palisades Reservoir. However, locations secured during extended periods when the radio-tagged eagle was out of sight, or when the observer was unsure of a location (within a 100 m^2 area) were not used in analyses.

Other resident adult bald eagles along the LSR were tracked visually when intensive, long term capture attempts proved unsuccessful. Two observers, one on each side of the river, one stationary the other roving, followed 1 pair (Dog Creek). Observation schedules were similar to those above for radio-tagged eagles. Although biased towards the river, observations and activities of these eagles were similar to those of radio-tagged birds. Observations of 2 other pairs (Hoback, Elbow) were more biased. Although the tracking schemes were similar to those above, observations were biased towards the nest site as eagles would often disappear from view and could not be subsequently located until returning to the nest area. Many other observations were serendipitous, obtained while traveling between pairs, on logistical runs, or during incidental tasks. Though biased towards the nest site, observations of these pairs were representative of use along the LSR and included in analyses.

Tracking of radio-tagged immature and subadult bald eagles was sporadic, accomplished mostly when manpower and logistics permitted. Radio-tagged nonadults were incorporated into monitoring schedules while residing in or near home ranges of resident adults. Once immature eagles left the area, periodic aerial surveys were conducted throughout the ecosystem to record locations and habitats used.

Activities of all eagles were recorded in a notebook in narrative style (Hall and Kelson 1959). Additionally, each perch, roost, and foraging site and flight path was recorded on a photocopy of an appropriate section of USGS 7½ minute Quadrangle map, including times. Each days movements were transferred to tracing paper, verified, and stored for analysis.

Data Compilation and Analysis

Reproductive Performance

Productivity terminology follows that proposed by Postupalski (1974) and Steenhof and Kochert (1982). However, use of the term territory is avoided. Strict, traditional definition of territory is often inappropriate when considered in the context of productivity assessment due to difficulty of determining spatial and behavioral territoriality. The phenomenon of seasonal territoriality and unpredictability of response to intruders (as shown by this study) confounds definition. In some areas territorial behavior appears extremely seasonal and selective (Flath et al. 1992). Therefore, the term breeding area is employed[1]. Nesting activity data from 1978 through 1984 were gathered from WGFD records. WGFD provided additional nesting activity information from 1985 through 1990.

Management Units

River Mile Segments

The Snake River was divided into 1 mile (1600 m) long segments to maintain consistency with U.S. Forest Bridger-Teton National Forest (BTNF), Jackson District, Snake River Management Plan (BTNF 1987). River Mile Segments (RMS) began at the Wyoming-Idaho State Line and progressed sequentially upstream along the mid channel line of the Snake River, to YNP, Wyoming.

Lake Shoreline Segments

Jackson Lake was divided into Lake Shoreline Segments (LSS) for analysis. LSS were delineated by placing the axis point of a drafting compass at the south shore outlet of Jackson Lake and scribing an arc of 1600 m on a 7½ minute topographic map. The point at which the arc intersected the shoreline, farthest from the origin in a clockwise direction, was the segment termination. Sequential LSS were drawn by placing the compass axis on the shoreline intersection of the previous LSS and scribing another arc, progressing clockwise around the lake shore. Island shorelines were segmented as mainland shoreline but initial segment origin was located at the farthest southeast point of the island. Islands ≤ 200 m from shore or each other were included in the same LSS or island complex. Boundaries between LSS were extended lakeward at 90° from general shoreline trend to separate island groupings bordering successive LSS. LSS were constructed for each of 3 water levels of Jackson Lake occurring during the study using Bureau of Reclamation water surface elevation data.

Habitat Mapping

Characteristics and distributions of habitat components important to bald eagles were determined from appropriate 7½ minute topographical maps, aerial photos and ground truthing. River morphology in the LSR was mapped by direct observation during August

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[1]. A breeding area is defined as the geographical area containing a nest site currently or previously occupied (within 10 yrs) by a pair of bald eagles during the breeding season.

1987 and plotted on 7½ minute topographic maps. River channel, islands and habitat characteristics in SP were traced from aerial photographic prints (1:24,000 scale) taken in August 1986. Tracings were photocopied and reduced for compatibility with 7½ minute maps. Morphology of the Snake River in ST (excluding up stream of Jackson Lake) was mapped from photographic slides, taken during aerial surveys in August 1989. Slides were projected on a corresponding portion of a 7½ minute map; scale compatibility was achieved by varying the distance of the projector to the map, and current river profile traced on tracing paper overlays.

Habitat parameters determined from observations, maps of the LSR and tracings of SP and ST within 3.2 km of shoreline in each RMS were digitized (x - y coordinates assigned to points, lines). GEOSCAN [Montana Dept. of Fish, Wildlife and Parks (MDFWP) 1984], a computer based system residing on a Digital Equipment Corporation VAX Scientific Subsystem main frame computer at MSU was used in data analyses. GEOSCAN is a collection of geographic information programs which relate animal locations with geographic/habitat data. GSDIG subprogram of GEOSCAN constructs user specified point (e.g. house, perch), line (e.g. road) and area (e.g. lake, village) files based on Universal Transverse Mercator (UTM) coordinate system . Number, length and area of each habitat type was determined by GEOSCAN subprograms GSL2D and GSA2D.

Treatment of Eagle Locations

Eagle locations were categorized by PERCH, NEST, PREFORAGE and FORAGE locations. A PERCH location was any eagle location detected, either visually or triangulated by telemetry where an eagle stood: i.e., on a tree branch, in water, on ground or human-made structure. PERCH locations were generally uncategorized as to activity but were considered to indicate at least security habitat. NEST locations included all bald eagle nests for which occupancy/activity/productivity data were available and complete, 1978-1988, including alternate nests. PREFORAGE locations were considered any nonflying eagle location occupied immediately prior to a foraging attempt. These locations were considered proximate to suitable bald eagle foraging habitat, more so than standard PERCH locations. A FORAGE location was where an eagle obtained or attempted to obtain food.

Weighting Bald Eagle Locations

Field observations indicated some perches obviously used more than others (i.e. "preferred"). Only PERCH locations for which frequency and duration of use were known were weighted. Each PERCH location was weighted using criteria based on the following assumptions:

1. A PERCH location used frequently was more important than one used infrequently.

2. A PERCH used for longer periods per perch event was more important than one used for a shorter duration per perch event.

3. The relationship was linear. Weighting was also considered in the context of total time monitored for individual birds. Therefore, the following formula was derived:

$$W_x = ln_x[Tm(F_pT_p)]$$

where: W_x = weighted value for perches used more than once (rounded to nearest whole number) and frequency that perch "p" was used in analysis (number of replicates),

F_p = Frequency perch p was used (number of events),

T_m = Total time eagle was monitored,

T_p = Total time on perch p.

Analyses of Habitat Use

Habitat associated with bald eagle locations was analyzed by considering spatial and temporal relationships of eagle locations to specific components of the environment. Components of habitat considered important or potentially influencing bald eagles, within RMS and LSS of the shoreline of the Snake River, were digitized from USGS 7½ minute quadrangle maps using GSDIG subprogram of GEOSCAN. Habitats were ground truthed on site during autumn 1987 and 1988. Habitat components were categorized into line, point, or area files. Daily tracings (Field Data Recording Procedures) of respective eagle locations were sequentially overlayed on a base map on DEC digitizing tablet and all eagle locations and nest sites digitized for analysis.

Spatial Habitat Use

Distances of PERCH, PREFORAGE and FORAGE locations to respective active NEST locations were calculated by GEOSCAN subprogram MDPP. Cumulative percent curves for distance, weighted PERCH to NEST, PREFORAGE to NEST and FORAGE to NEST locations were plotted and fitted to the logit equation:

$$y = e^{g(x)}/[1 + e^{g(x)}]$$

where: e = exponential function (2.718)

$$g(x) = B_o + B_1(x)$$

Actual and theoretical distances from the nest containing 50%, 75% and 90% of each location category were calculated for all curves for each eagle (or pair) investigated.

Use Area Description

Bald eagle use areas were delineated by plotting all detected PERCH locations within an eagle's or eagles' range on tracing paper overlays over an appropriate USGS 7½ minute topographical map. A 200 m radius circle was drawn around each location. The 200 m radius was considered a scanning zone and based on integration of results of eagle responses to human activity and preforaging perch to foraging site distance analysis of resident eagles only. Eagles flushed from encounters with all types of human activity more often at distances less than 150 m but a significant downward trend of percent flushes from all encounters was evident at greater than 200 m (see Results: Bald Eagle responses to Human Encounters). Although there was no significant difference between flush and nonflush distances, 74% of all flushes observed occurred at distances of 200 m or less. Upper limit of 95% confidence interval for all flushes of resident eagles was 234.6 m but upper limit of 95% confidence interval for the area with the largest number of observations (LSR:22) was 193.3 m. Presumably, LSR flushing distances represent toleration of human activity within threshold limits, considering that productivity and occupancy of resident pairs was adequate.

The periphery of coterminous, overlapping circles formed distinct, independent clusters and determined boundaries of use areas. Relative size of clusters (use areas) was determined by overlaying tracings of each discrete use area on a dot matrix grid (9 dots/cm^2). Number of dots contained in the area measured equaled area magnitude. Use intensities of High, Medium or Low were assigned to use areas based on magnitude of perch weights and area of clusters, relative to others within an eagle pair's range.

Use area weights within an eagle's range were evaluated by the formula:

$$I_{cx} = lnx\Big[(W_{cx}\,A_T)\,(10/W_T\,A_{cx})\Big]$$

where; I_{cx} = Use intensity of cluster x

W_T = Total weight of all perches use by eagles in home range (See Weighting Bald Eagle Locations)

W_{cx} = Weight of perches in cluster x

A_T = Total area of clusters within an eagles range

A_{cx} = Area of cluster x

Use areas were categorized by season in relation to nesting phenology of bald eagles in the GYE. Seasons defined were: EN = 1 March - 31 May; LN = 1 June - 31 July; PF = 1 August - 30 September; F = 1 October - 15 November; W = 16 November - 28 February.

Habitat Selection in the Lower Snake River

Due to a large variety of development and recreational pressure in the LSR, aspects of bald eagle habitat selection were analyzed more intensely. Habitat selection analyses in LSR compared habitat relationships of eagle locations and nest sites to habitat relationships of locations not used (not observed).

All NEST locations were weighted. Weighting was a function of number of years an eagle pair attempted reproduction (active), number of years productive and total young produced between 1978 and 1988. A nest was considered more important when activity and productivity were high. The resultant formula was:

$$W_{Nx} = l_{nx}\Big[Y_{\Sigma x}\ x\ 100/Y_{ay}\Big]$$

where: W_{Nx} = weight of nest x

Y_{ay} = number of years Eagle pair Y attempted reproduction

Y_{px} = number of years nest x was productive

$P_{\Sigma x}$ = number of young produced in nest x

W_{Nx} indicated the frequency NEST location x was used in analyses.

Frequency distributions of actual PERCH, PREFORAGE and FORAGE locations of radio-tagged eagles along the LSR were used as a model for distribution of nonused locations. Nonuse locations were distributed in relation to their corresponding use category (PERCH, NEST, PREFORAGE, FORAGE). The result was a combined stratified, systematic and random distribution of nonused locations (Appendix Table 1).

Habitat selection was determined by measuring minimum distance of used and nonused eagle locations to 24 habitat components (Table 3) and comparing differences in distances among used and nonused locations. Parametric statistical tests and Stepwise Discriminate Analysis (Procedure STEPDISC: SAS 1988) were used to detect differences between used and nonused locations and their respective distances to habitat components.

Four scenarios were tested to best discriminate between habitat component relationships and used and nonused FORAGE locations:

1. All weighted FORAGE locations employing all 24 habitat components,

2. Weighted FORAGE locations except those of eagles which include a portion of a lake in the home range, employing all 24 habitat components,

3. As in 2, but employing only water associated habitat components except those associated with lakes (Palisades Reservoir).

4. As in 1, but employing all water associated habitat components.

Evaluation of Habitat Quality and Quantity

River Diversity Index

Habitat characteristics chosen to calculate a River Diversity Index (RDI) reflected availability and abundance of food, primarily waterfowl and fish. Deep and shallow pools and runs, riffles, islands, and streams all influence fish and waterfowl use, behavior and temporal use patterns (Baxter and Simon 1970, Brown 1971, Lockman, D. pers. comm., Hayden, P. pers. comm.). The amount of channelization also influences prey availability and abundance and where present, levees were considered. Human activity was not considered in RDI calculation. Habitat parameters were defined as follows:

1. Riffles (RIF) - Shallow areas usually less than 60 cm deep with broken surface flow, digitized as a *point* habitat type.

2. Deep Run (DR) - Areas where current velocity was usually between 60 cm and 150 cm per second with a depth of > 150 cm, digitized as a *line* habitat type.

3. Deep Pool (DP) - Areas where water depth ≥150 cm and current velocity <60 cm per second with smooth or laminar surface flow, digitized as a *line* habitat type.

4. Shallow Run (SR) - As Deep Run but water depth was <150 cm, digitized as *line* habitat type.

5. Shallow Pool (SPo) - As Deep Pool but water depth <150 cm, digitized as a *line* habitat type.

6. Levees (LEV) - All earth, stone (rip-rap) or masonry dikes, dams or water diversion structures, digitized as a *line* habitat type.

7. Islands (ISL) - Any non-water area within the stream channel, surrounded by water. Islands were either permanent or ephemeral, i.e. may not be evident at high water, digitized as *area* habitat types.

Two RDIs for the Snake River were developed. Each was modeled after Shannon's diversity index (Shannon 1948). RDI formula developed for the LSR was:

$$RDI_x = Pix \log Pix + \log \left[N_{RIFx} + (1+N_{ISLx})\right]$$

where: RDI_x = Diversity index for RMS_x (0-31) and,

Pix = Proportions of total linear distance in RMS_x (1600 m) covered by i category of river habitat type in RMS_x,

N_{RIFx} = Number of riffles (point habitat) in RMS_x,

N_{ISLx} = Number of islands in RMS_x,

log = base 10.

i categories were DP, DR, SPo, and SR. Islands were assumed to provide more habitat conducive to prey abundance and availability than riffles, hence an increase of 1. Proximity relationships among habitat types have been shown to influence bald eagles (Haywood and Ohmart 1986) but interactions of categories were not included RDI derivation. All variables measured were considered to influence the RDI in a positive manner.

A second RDI was developed for RMS 32 through 90 (SP through ST) due to the presence and abundance of conditions not immediately relative to the LSR. The formula for RDI was:

$$RDI_x = P_{1-4} \log (P_{1-4}) - P_5 \log (P_5) + N_{1,3} \log N_{1,3} + (N_{2,4}+1) \log (N_{2,4}+1)$$

where: RDI_x = Diversity index for RMS x (32-90) and,

P_1 = Proportion of total linear distance in RMS_x (1600 m) covered by DR in RMS_x

P_2 = as for P_1 but habitat type is DP

P_3 = as for P_1 but habitat type is SR

P_4 = as for P_1 but habitat type is SPo

P_5 = as for P_1 but variable is Levees (LEV)

N_1 = Number of riffles (RIF) in RMS_x

N_2 = Number of islands (ISL) in RMS_x

N_3 = Number of intermittent stream confluences (IMS) with the Snake River in RMS_x

N_4 = Number of permanent stream confluences (PERS) with the Snake River in RMS_x

Derivation of RDI

ISL and PERS were increased by a factor of 1 because intuitively each provided more diversity to an RMS than that reflected in absolute number. LEV were considered to reduce diversity and therefore had a negative influence on RDI, otherwise RDI was a cumulative formula, without considering interactions among variables, which certainly exist.

If any variable was <0.37 but >0, then $P_i \log (P_i)$ and/or $N_x \log (N_x)$ was replaced by $.002496(P_i-0.37) - 0.159765$. This maintained a monotonically increasing function. For each $P_i = 0$, 0.1606885 was added to always yield a positive effect. A FORTRAN program was written and employed to calculate RDI (Appendix III).

Home Range Diversity Index

A Home Range Diversity Index was developed to compare habitat diversity among home ranges of each bald eagle pair that nested along the Snake River. Quantification of habitat diversity within home ranges was accomplished by summing each habitat parameter in each RMS (e.g., DR, DP, ISL, etc., above) contained within an eagle's home range, divided by number of RMS included in the home range. Resultant calculation was:

$$Pi_{hrx} = \Sigma Pi_{rmsx} / N_{rmsx}$$

where P_{hrx} = total (length or number) of habitat parameter i within all RMSs included in home range of eagle pair x, N_{rmsx} = total number of RMS included in home range x.

Comparison of Home Range Diversity Indexes among eagle ranges included a modified calculation of the ISL parameter. Intuitively, number and area of islands interact to affect the diversity of a home range, i.e. many small islands have more shoreline than few large islands, to a point. Accordingly the relationship between number and area of islands within a home range was expressed:

$$ISL = l_{nx}[4n\sqrt{A_x/n_x}]$$

where n = number of islands in home range x; A_x = total area of islands in home range x. Derivation of this equation considered islands as conceptually square.

Lake Shoreline Diversity Index

A Lake shoreline Diversity Index (LDI) was derived using the same formula as the RDI for the Snake River from SP to ST (pg. 12). Variables included for calculation of the LDI are shown in Table 4.

Length of developed shoreline was included as a measure of human activity and considered a negative influence on diversity. Shoreline of mainland and islands and number of islands were considered to influence overall diversity of habitat; increased proportions, increased suitability of habitat for more species of flora and fauna. Depth was a measure of amount of shallow water, greater values were considered an indicator of conditions conducive to the presence of suckers (Catastomidae), a commonly taken prey species of bald eagles in the GYE. Shallow water was often associated with macrophyte production, a condition which attracted high waterfowl numbers in spring and fall. Fish also congregated in shallows during invertebrate hatches and at mouths of peripheral streams during summer where cooler water entered the lake.

Habitat Removed by Human Activity

Cumulative effect of human activity on behavior, activity and habitat use of wildlife species is a relatively new concept in wildlife management. The importance and pertinence to bald eagle behavior cannot be overstated and the concept has been intuitively obvious to many field observers for a long time. Montopoli and Anderson (1991) developed a unique and imaginative approach to assessing cumulative effects of various water associated human activities on the percent habitat available to bald eagles on the Snake River. Amount of foraging and perching habitat available was evaluated based on amount of recreational and other human activity that impacted areas of predetermined size. The Cumulative Effects Model (Montopoli and Anderson 1991) was employed here to evaluate percent habitat remaining (perching or foraging) based on human activity or presence in an area of predetermined size. *Throughout this document, percent bald eagle foraging or perching habitat remaining as determined by Cumulative Effects Model analysis will be expressed as CEM.*

Human activity and location data were provided by BTNF, GTNP, angler census flights conducted by WGFD in 1985 and activity levels and locations observed during the study. The Snake River was divided into 7 segments (5 covering South Park bridge to Jackson Lake). Only data from July through September was used because extremely low use in October would have artificially lowered mean use for the entire season. Number of boat fisherman and boats on each river segment for each flight was averaged. Number of boats was divided by number of RMS in each segment to obtain number of boats per mile. Number of bank fisherman in each segment was multiplied by percentage of fisherman use in each RMS (J. Kiefling, WGFD, Jackson WY) to obtain number of bank users per mile segment.

Length and distance of vehicle pulloffs (paved and unpaved widened areas off Hwy 289) to Snake River were measured from USGS 7½ minute topographical maps. Only pulloffs within the maximum distance considered by Montopoli (1988, p. 50) were used in percent habitat remaining calculations.

Human activity in the LSR was less seasonal than in SP and ST. Relationships of bald eagle perches with percent habitat remaining and RDI were analyzed with overall perch weights determined for LSR eagles. Influence of each on perch selection of radio-tagged eagles in SP and ST was investigated by including only perches used during late nesting (LN) and post-fledging (PF) seasons; periods when human activity data were most pertinent and available. Perch weights for all river nesting eagles in SP and ST were recalculated by employing the formula:

$$W_e = lnx\left[Fp^2Tp(Tm/Te)\right]$$

where: W_e = Weight of perch used by eagle e,

Fp = Number of visits of eagle e to perch p,

Tp = Total time (in 5 min intervals) eagle e spent on perch p in seasons LN and PF,

Tm = Total time all eagles nesting along the Snake River in ST and SP were monitored during LN and PF seasons,

Te = Total time eagle e was monitored during LN and PF seasons.

Perch weights were recalculated for Butler Creek (SP), Schwabacher (GTNP) and Oxbow Female (ST). Recalculated perch weights in each RMS used were totaled for an RMS weight. RMS weight was then used in regression analysis with RDI and CEM.

A second analysis was conducted by correcting RMS weight using proportional frequencies and durations of eagles in an RMS relative to all those where CEM data were available. The formula derived was:

$$RMS_x = lnx\left[Frms_x Trms_x (Tm/Te)\right]$$

where; RMS_x = weight of RMS_x,

$Frms_x$ = number of visits of all eagles to RMS_x,

$Trms_x$ = duration (in 5 minute periods) spent on all perches used in RMS_x,

T_e = time all eagles using RMS_x were monitored,

Tm = time all River eagles monitored in LN and PF season.

RMS_x weights were regressed against CEM and RDI values for respective RMSs.

Data analysis revealed CEM values for some RMSs changed over circadian time in GTNP. A method of assigning RDI and CEM values to a perch independent of RMS, was developed for analysis of Schwabacher Male's perch selection. CEM data by time period were available from May to September, between 0800 and 1800 hr (Montopoli 1988: Table 8). A formula was derived to assign a weight value for perches used during time periods where complete data were available. RDI was not considered to change. The formula employed for weighting perches was:

$$Pw_x = lnx\left[(F^2 rms_x\ cem_{x)(}\ trms\ cem_x)\right],$$

where: $Frms_x\ cem_x$ = number of eagle visits to RMS_x with CEM value x,

$trms_x\ cem_x$ = duration (min) Schwabacher Male was perched in RMS_x at CEM value x.

Resultant perch weights were regressed with respective time specific RDI and CEM values, and fitted to the high order response surface, multiple regression formula (Snedecor and Cochran 1988):

$$Y = B_o + B_1\left[(x_1 - m_1)/s_1\right] + B_2\left[(x_2 - m_2)/S_2\right] + B3\left[(((x_1 - m_1)/s_1)2)\right] + B_4\left[((x_2 - m_2/s_2))\right]$$

Habitat Suitability Index

The interaction of habitat quality (RDI) and quantity, expressed as amount remaining (CEM), was investigated by comparison of a Habitat Suitability Index (HSI) with various eagle use parameters. HSI was developed by simply multiplying RDI of each RMS with respective CEM value for perching habitat. Perching CEM was considered more representative of overall eagle needs than just foraging CEM because motivation for perch (and RMS) use could only be subjectively determined, unless a foraging attempt was made. Perching CEM was considered to cover most eagle use scenarios, whether selection and use of a perch was dependent on loafing or foraging needs, avoidance of human activity or desired respite from persistent, oppressive juveniles constantly and aggressively begging for food.

Home Range Determination

Home ranges of adult bald eagles were determined by minimum convex polygon method (Mohr 1947, Jennrich and Turner 1969, Andersen et al. 1990). Locations of the Third Creek Male beyond 10 km of Jackson Lake were associated with long range movements to wintering grounds and were not included in the breeding home range.

Temporal Relationships

Foraging attempts per hour period were considered indicative of eagle activity. In an effort to detect differences in foraging times and success potentially influenced by monitoring effort and season, data were segregated into 2 periods and corrected for proportional differences in monitoring time. Periods were selected based on presence and intensity of recreational activity in GTNP. The Period 1 June through 31 August was considered a time of intense and dispersed recreational activity while 1 September through 31 May was considered a time of little or no activity. Data were corrected for proportional monitoring differences by employing the following formula:

$$P_{fa} = [60Fax]/Tmx$$

where P_{fa} = corrected foraging attempt rate, Fax = number of foraging attempts of any category (i.e. total, successful, etc.) recorded in hour period x (e.g. 0900-1000 hrs.) and Tmx = total time monitored in the respective hour period x.

Weather Severity Index

Swenson et al. (1986) felt weather was a significant factor affecting productivity of bald eagles in the GYE. Therefore, a Weather Severity Index (WSI) was derived incorporating meteorological data from 4 recording sites in the SW (Fig. 4). Data were obtained from National Oceanic and Atmospheric Administration - National Weather Service, Asheville, N.C. 28801-2696. National Weather Service data covering only months of February through May 1985 through 1989 were incorporated into the index. These months spanned incubation and early nestling phases of bald eagles in the GYE (Swenson et al. 1986), periods when weather would most likely affect productivity. The index followed that devised by Picton and Knight (1971), however the transition point chosen was Lower Critical Temperature determined for bald eagles (Stahlmaster and Gessaman 1982). Resultant WSI calculation steps were:

$$Y_m = 10.6 - [(x-32).56]$$

If Y_m is positive (+) then $WSI_m=(Y_m)(S_m)$.

If Y_m = zero (0), then $WSI_m = S_m$.

If Y_m is negative (-), then $WSI_m = Y_m+S_m$,

where: Expression $[(x-32)0.56]$ is F to C conversion,

x = mean daily temperature (F°) for period m, (m = day, month, year),

S_m = mean daily snow cover (inches) for period m.

Weather was more severe when WSI values were large and positive and low when negative.

Daily WSI was calculated for each reporting station (Fig. 4). ANOVA (SAS 1988) was used to test for differences among stations for all days and all years. Mean "main effects tests" [Tukey, Gabriel, Bonferroni and Scheffee tests (SAS *op cit.*)] were used to determine where differences (if any) were and to determine groupings of bald eagle nest sites experiencing most similar weather conditions. Nest assignment to weather stations was determined by proximity and topographical similarities and was obvious. Regression analysis was employed to serve as a predictive model for weather effects on annual productivity.

Eagle Responses to Human Activity

Behavioral responses of bald eagles to human activity were noted throughout the study and study area. Reactions of perched eagles to many types of anthropogenic events were recorded. Anthropogenic agents potentially affecting eagle behavior were classified into 4 categories: vehicles, pedestrians, watercraft and miscellaneous. Watercraft were exclusively rafts, tubes or driftboats in the LSR and SP but included power and sail craft in ST, the latter restricted to Jackson Lake. Miscellaneous category included gunshots, low-flying aircraft and vehicle backfires.

Any encounter which resulted in the eagle leaving the perch was considered a "flush" and the distance between the eagle and the affecter considered "flushing distance". A flush was determined by evaluating behavior of the eagle prior to leaving the perch in order to determine whether the affecter was in fact anthropogenic or other agents beyond the perception of the observer, i.e. intruding conspecifics, hunger, foraging opportunity or internal stimuli. Encounters which elicited a flush most often were obvious as affected eagles clearly displayed behaviors of visual tracking, awareness, recognition, agitation or total disinterest of a potential affecter. Flushing distances were determined by noting location of the affected eagle and location of human presence or activity at time of flushing.

Distances were measured by optical range finder or by reference to objects of known location or measuring distance between locations plotted on a USGS 7½ minute topographical map. Potential affecters which did not elicit a flush response were also noted and the closest distance measured as above. Eagles usually did not respond to human activity beyond 800 m and, therefore, lack of response to events over 800 m generally was not recorded. However, apparent reactions to human activity beyond 800 m were noted in a few instances and were included in analysis.

All flushing distances noted in SP and ST were analyzed to determine if differences existed among the 4 categories. Only responses of *resident* eagles, both radio-tagged and nonradio-tagged were analyzed further.

In an effort to determine if habituation to human presence had occurred or if eagles selectively avoided human activity thereby minimizing interactions that would result in flushing or disturbance, time-lapse cameras were employed to record river use over extended periods in the LSR. Eight millimeter movie cameras were located on trees at 2 sites on the Snake River to record river use. One site was upstream of the Elbow (mouth of Bailey Creek). The second was located downstream of the Elbow, a popular boat launch for recreational river use. The upstream camera recorded river use considered to be low therefore the intervalometer was set to capture a frame every 4 seconds. The camera in the downstream was considered to be in a section of high use and set to capture a frame every 2 seconds.

RESULTS

Banding

Banding efforts in the GYE between June 1979 and October 1989 resulted in 288 bald eagles banded (Table 5). Nestlings comprised 257 (89%) of total. Most (52.8%) eagles were banded in Wyoming (outside of YNP) with the majority of those banded along the Snake River. Idaho followed with 38.9% then Montana with 8.3%. Eagles banded in the Yellowstone Unit which was primarily within YNP, comprised 10.8% of all eagles banded. Percentages reflected relative population size, productivity, agency interest and support.

Capture and Radio-tagging

Five nestling bald eagles were radio tagged with solar-powered backpack transmitters in summer 1985 (Table 6). Little was known about post-fledgling activities of juvenile bald eagles in the GYE, but the hope was that radio-tagged juveniles would indicate adult foraging areas by association and reveal potential capture sites for resident adults targeted for study.

Attempts to determine foraging areas and capture sites of adults by following radio-tagged juveniles failed. Juveniles were seldom in close association with adults post-fledgling. Juveniles apparently watched foraging adults from perches rather than following adults on foraging sorties. In some cases, perches of juvenile eagles were high on ridgelines adjacent to the Snake River. Adults that obtained food (always fish) would be joined by juveniles that would take the food. As powers of flight improved, radio-tagged juveniles continued to obtain food by pirating siblings and adults. Although the primary objective of radio-tagging juvenile bald eagles in the nest was not achieved, the procedure ultimately revealed unique and valuable data concerning population dynamics, habitat use and movements of bald eagles in the GYE. Therefore, 18 nestling and 3 recently fledged bald eagles were radio-tagged in the nest each year between 1985 and 1989 (Tables 6 & 7).

Capture efforts for adult bald eagles were distributed among pairs nesting primarily in the SW (Fig. 3). Initial intent was to capture only resident adult male bald eagles in each target breeding area. Adult males were suspected of doing the majority of foraging (Stahlmaster 1986) and movements and habitat use most representative of the pair. Also, range of the female has been shown to be included in that of the male (Gerrard et al. 1993). Initial radio-tagging strategy for resident male bald eagles required the use of rectrice-mounted transmitters. Capture operations therefore, were delayed until mid-October 1985 to insure that new, fully developed central rectrices were in place to mount radio transmitters. Observations as late as mid-September 1985 indicated that at least 1 central rectrice on every target adult eagle was insufficiently developed to support a radio transmitter. When capture operations were initiated, wariness of target eagles resulted in poor success. Several non-target bald and golden eagles were captured between 1 January and 28 February 1986 (Table 7).

Traditional capture methods were ineffective for resident adult bald eagles in the GYE. Eagles generally ignored floating noosed fish and carrion fish surrounded by padded leg-hold traps in shallow water. On at least 2 occasions, target adults perched over these baits and traps for at least 3 hours only to capture a live fish within 15 meters of trap sets. Aquatic trap sets were often disturbed by river otters (*Lutra canadensis*), mink (*Mustela vison*) and gulls (*Larus* spp.). Padded leg traps with large ungulate baits in terrestrial situations resulted in captures of ravens (*Corvus corax*), golden eagles and juvenile, immature and subadult bald eagles. Capture of nontarget animals increased wariness of target adult bald eagles that witnessed the event. However, one adult bald eagle was captured with padded leg traps within a resident home range on 23 January 1986 but proved to be a migrant that wintered in the GYE (Refuge male: Table 7).

Poor success dictated the design and construction of a selective, remote-controlled trap. A radio-controlled bownet (n.b. Meng 1963) was employed for capture of adult bald eagles on 5 February 1986 and used almost exclusively thereafter. Between 5 February and 8 March 1986, 12 trap sets with the bownet were made. Several sets were left in place up to 5 days. Snow, rain, varying temperatures, mistakes in setting procedure and defective batteries resulted in missing and subsequently "educating" 5 target eagles. The first resident adult eagle was captured with a bownet on 28 February 1986. The onset of breeding activity dictated the cessation of all capture attempts in early March in order to avoid any potential impacts of trapping activities on bald eagle productivity. Capture operations recommenced on 7 April 1986.

Results of subsequent capture activities revealed that adult males were often the most wary of situations associated with trap sites. Consequently, expediency dictated that resident adults of either sex be captured when possible.

Difficulty and unpredictability of capture of extremely wary resident adult bald eagles required a change from rectrice-mounted transmitters to the employment of solar-powered backpack transmitters. Backpack systems permit attachment independent of molt; therefore, adult eagles could be captured during any season. Rectrice-mounted transmitters dictate capture only during a short period in early autumn to be most efficient. New tail feathers are fully developed to support transmitters at that time, but radios will be retained only until the following August. Backpack mounts can be attached for eventual release but with much less certainty concerning retention time. Rectrice mounts subsequently were employed only on eagles considered migrant and nonresident.

Capture Effort and Success

Time expended to capture at least 1 member of 14 target pairs of bald eagles (and selected fledglings) was 3845.9 personnel hrs. In perspective, nearly 1.5 years (16 months!) were consumed with capture-related activities. Capture operations using padded leg-hold traps consumed 270.9 personnel hours between 27 November 1985 and 15 February 1986, with no target eagles captured. Considerably more effort was involved in placing the radio controlled bownet but it was decidedly more selective, less educating to target eagles and more successful. Average trap setting time, not including preliminary observation or travel time, averaged 1.5 hrs per set.

Trapping methods and procedures continually evolved throughout the study as optimal site characteristics and bait were determined and experience in preparation, transport and setting of the bownet accrued. As trapping savvy developed, distribution of time expended for activities associated with capture improved and are most accurately represented in Table 8. Approximately 3575 personnel hrs were involved in capture operations with the bownet between 15 February 1986 and July 1988.

Time expended with capture-related activity was related to season. In summer, traps took between 44 and 50% of total capture time to produce a target eagle, while in winter only 7%; but that was only for successful captures. Amount of total capture time consumed for a set trap to produce a target eagle (roughly related to time required for a target eagle to visit the trap set) was inversely related to amount of pre-baiting time (Table 8). The more time pre-baits were available, the less time passed for a target eagle to visit a site once the trap was set. Data in Table 8 are presented only for successful captures in ST.

Some pairs consumed a large portion of total time expended during capture attempts and were never caught. The Dog Creek pair consumed over 500 hrs of capture time but eluded capture. Other pairs which eluded capture in descending magnitude of trapping time expended were Hoback, Fords, Gros Ventre, Moose, Gills (Fig. 3). Overall, 31 bald eagles were captured resulting in 124.1 hrs expended per eagle. Thirteen target adult eagles were captured and radio-tagged (Table 9) with 295.8 hrs per eagle expended. Specific to adult male bald eagles, 427.3 hrs were expanded in capture related activities for each target male caught. Additionally, 18 migrant or nonadult eagles were captured and most radio-tagged (Table 7).

Monitoring

Over 519 (4152 hrs) personnel days were expended monitoring 40 radio-tagged bald eagles in the GYE between June 1985 and September 1989. Most monitoring time (77.8%) was spent tracking 11 resident adult bald eagles (Table 10), with the remaining 22% distributed evenly between tracking non-adult and migrant eagles (Table 11) and eagles radio-tagged as nestlings (Table 6). Mean number of hours tracked per monitoring day per eagle was 4.22 for resident adults and 3.79 for eagles radio-tagged as non-adults or migrants.

Intensive tracking of eagles radio-tagged as nestlings was not consistent with stated agency objectives of study. Several returning eagles were nevertheless intensively tracked during years subsequent to fledging, capitalizing on unique circumstances and juvenile survival (see Movements of Juvenile and Immature Bald Eagles and Population Dynamics). Hours calculated for tracking eagles radio-tagged as nestlings reflect only monitoring time spent tracking during the year they were radio tagged, i.e. post-fledging to departure from the ecosystem on autumn migration. Also, many were located by aircraft during surveys of the entire ecosystem and only date, time and location were recorded.

Four pairs of resident bald eagles were monitored visually in SP and LSR Three pairs were monitored sufficiently long enough and under conditions which allowed analysis of home range, foraging habits and use areas (Table 12).

Unusual Plumage Characteristics

Nestling banding, capture of free flying eagles and incidental observations during surveys and radio tracking revealed unusual plumages in bald eagles in the GYE. On 20 June 1981 during banding operations at the Oxbow nest in GTNP (Fig. 5, Site A) observations from the ground revealed that both nestlings exhibited a white wedge of feathers on the head. Only heads of nestlings were visible from the observation point, but white feathers appeared to cover the crown and chin of both nestlings. Unfortunately, no photos were taken and these were the first nestling bald eagles the climber banded. When questioned post-banding, the bander stated he had not noticed any abnormalities (bald eagles are *supposed* to have white heads!). The incident was noted and forgotten.

On 17 June 1985, both nestlings from the Butler Creek nest (Fig. 5, Site B) were lowered to the ground in a canvas bag for banding. Similar to the Oxbow nestlings in 1981, both exhibited the white wedge of head feathers. The apex of the wedge emanated from the proximal cere dorsally, progressed across the forehead and crown, and terminated in the anterior occiput region. Both eaglets had several white talons and white feathers predominated on the abdomen, chin, and breast. The rictus to commissural points and proximal dorsal cere adjacent to white feathers were bright yellow. This was the first confirmed observation of atypical plumage and talon coloration in bald eagles of the GYE. Both eaglets were banded; one was radio tagged, and they were returned to the nest. Both fledged normally in late June

1985. The female was last located alive and healthy in July 1989 along the Snake River in the Idaho portion of the GYE but natural progression of white plumage and distance of observation precluded assessment of persistence of pied plumage.

In April 1986 the adult female at the Butler Creek nest site was captured, banded, and radio tagged. Coloration of her plumage and talons were normal. The adult male also appeared normally colored (as could be determined through spotting scope at 50 m). Both nestlings produced that year had normal plumage and talon coloration. In 1987 one of 2 Butler Creek nestlings again exhibited plumage similar to that described for 1985. One of 3 nestlings at this nest also had atypical plumage in 1988. The parent female eagle was the same from 1986-1988 as confirmed by band.

In June 1986 a near-adult (Clark 1983) malnourished female bald eagle was encountered on the bank of the Snake River (Fig. 5, Site C) less than 3 km from the Butler Creek nest. She had damaged right primary feathers and an injured right eye. The eagle exhibited 3 white talons and a few white feathers on the proximal leading edge of the patagium. The eagle was rehabilitated and released on 5 February 1990.

During productivity surveys in June 1986, the adult female at the Moose nest (Fig. 5, Site D) had a distinct white patch on the breast, approximately 2 x 2 cm. In December 1986 an injured adult male bald eagle was recovered within the Moose eagle pair's home range. The residency status of this eagle was not established definitively, but he exhibited one white talon. No nestlings with aberrant plumage were noted at the Moose site in 1986.

In June 1988 one of 2 siblings banded at the Oxbow nest again exhibited atypical color patterns. When captured in July 1988, the adult female at the Oxbow site had several white feathers on the lateral crus of both legs. Four talons were also partially colored white. Nestling eagles produced at the Oxbow site in 1990 resembled those seen there in 1981 and at the Butler Creek site in 1985. The parent female eagle at the Oxbow breeding area was the same as captured in 1988, as confirmed by radio signal and colorband configuration.

During banding operations at the Munger Mountain nest (Fig. 5, Site E) in May 1987, one of 2 nestlings exhibited plumage and talon coloration similar to the Butler Creek nestlings in 1985. The atypical eaglet (a female) had much yellow on the proximal cere (normal colored nestlings have no yellow on the cere). Number 8 primary on the left wing was totally white. A colorbanded immature bald eagle displaying atypical plumage was observed less than 2 km from the Munger Mountain nest in April 1989. It was most likely the same eaglet banded there in 1987 because plumage was consistent with that of 2-year-old immature bald eagles while also incorporating white feathers of the atypical plumage. A nestling bald eagle in eastern Idaho (Fig. 5, Site F) also had similar atypical plumage when banded in May 1988. No other bald eagles exhibiting these atypical plumage or talon colorations were observed during banding or surveys of nesting bald eagles at other sites in the GYE nor surrounding 3 states.

USFWS Band Encounters

Excluding colorband sightings and telemetry locations, 9.4% of all eagles banded in between May 1978 and July 1988 were subsequently encountered as of June 1990 (Table 13). Direct encounters (bands encountered in the same calendar year as applied) comprised 37% of total. Seven of 10 direct encounters were of eagles banded as nestlings. Only 2 of the 7 were recovered in the GYE and both before October. The remaining 5 (50%) direct encounters were well outside the GYE and all were between October and mid-December.

Sixteen encounters were obtained within the first 12 months post banding but in the next calendar year (indirect encounter). Five were from areas west of the GYE and 4 during winter or early spring. Indirect encounters within the GYE obtained after 12 months post-banding (11) occurred during all seasons but eagles encountered tended to be older (x = 4.4 yrs) than those encountered outside the GYE ($\bar{x}$ = 1.8 yrs).

Mean number of years from banding for indirect encounters was 3.7. This was equivalent to mean age of eagles encountered (range 0.9-9 years) because all eagles encountered indirectly had been banded as nestlings.

Twelve (75%) of 16 banded eagles encountered within the GYE were encountered within the same population unit as banding (Fig. 6). Most (8 or 66.6%) were indirect recoveries. Only 4 (25%) banded eagles encountered within the GYE originated from a different population unit but 3 of those 4 were also indirect encounters. Of eagles encountered in population units other than where banded, habitat types were similar between banding and encounter units (i.e., ST to SI, YU to CI) and all were associated with major lentic or lotic systems (Fig. 6).

Eleven eagles were encountered outside of the GYE (Fig. 7 & Table 13) comprising 40.7% of all encounters. Oregon contained the largest proportion of extra-regional encounters with 36.4%. Montana, Utah and Washington all had 2 each or 18.2% of all encountered followed by Idaho with one (9%). An obvious westward movement from the GYE for newly fledged eagles evident is from encounters.

Circumstances of encounter varied greatly and illustrate the multitude of dangers to which bald eagles are exposed. As with the majority of bird band encounters, the largest category of encounter reason was "unknown" (Table 14). The second largest category illustrates the value of intensive banding *and* capture operations in breeding areas for information concerning population dynamics. More banded eagles were encountered during capture operations than for any other known reason. All mortalities of known cause were from a variety of anthropogenic causes or conflicts.

Sightings of Auxiliary Marked Bald Eagles

Extra-regional sightings of bald eagles colorbanded in the GYE occurred in 4 western states (Fig. 8) but most frequently in California. All but 2 sightings were of eagles whose plumage description matched those of eagles 2 yrs-old or less. Most sightings were of eagles colorbanded in the SP or LSR and were represented in all 4 states. A colorbanded bald eagle was observed perched above the Madison River, Gallatin Co. in southwestern Montana (Fig. 8, SWBA) on 30 May 1989. The eagle was an adult male and wore a plastic colorband indicating he was banded prior to 1987 and probably prior to 1985. If banded prior to 1985, color and leg banded indicated only that population unit of origin was not YU. He was subsequently observed associated with an adult female and in March 1990 was a member of an active pair.

All sightings of colorbanded eagles were associated with marine, lentic or lotic systems, except SW(A) (Fig. 8). This exception was an adult female observed in an upland situation in the vicinity of an elk (*Cervus elaphus*) feedground during early February.

Sightings of GYE colorbanded eagles within the GYE were common. Fifty-eight sightings were distributed through all population units, were of all plumage (age) classes and represented all natal areas of origin (Table 15). All were associated with major rivers, lakes or reservoirs. Often eagles of several age classes and population units were observed together.

Areas where eagles originating from different natal areas within the GYE congregated were most notably the Oxbow in GTNP, the Snake River in SP, LSR, Palisades Reservoir and Henry's Lake, Idaho, and Hebgen Lake and Cliff Lake, Montana. A larger proportion (74.1%) of colorbanded eagles observed were seen outside of their population unit of origin than within (25.9%).

Only 3 of 62 sightings of non-adult colorbanded bald eagles occurred during winter months (Nov.-Feb.) but the 3 were in mid- to late February. The preponderance of sightings of non-adults (63%) occurred in spring and autumn, between 10 March and 30 May and 1 August and 30 October, respectively. Sightings of colorbanded adult bald eagles that were not immediately identified with a known breeding area (16) were more evenly distributed throughout the year. Five sightings of colormarked bald eagles that originated extra-regionally (red patagial tags or streamers) were in mid-winter (4) or early spring (April). Four eagles were marked in autumn over several years in Glacier National Park, Montana (B.R. McClelland pers. comm.). Two were observed in the SW and 2 were on the Firehole River in YNP. Another adult bald eagle with red "streamers" was observed in the LSR during winter but origin could not be confirmed.

Four bald eagles radio-tagged in nests in central and southern Arizona were located in the GYE (Hunt et al. 1992). All were in early summer and were associated with Upper and Lower Red Rocks Lakes and Yellowstone Lake. Additionally, a juvenile bald eagle wing marked as a nestling on the Gulf Coast of Texas was observed on Quake Lake in southwestern Montana (CM) in June 1986 (D. Marbie pers. comm.).

Population Demographics

Nesting Population

Surveys of nesting bald eagles in the SW were conducted by WGFD and others between 1978 and 1990. Surveys identified 21 distinct breeding areas, occupied by 21 pairs of eagles by 1990 (Fig. 3). Number of breeding areas gradually increased during 13 years of surveys. In 1978, 12 breeding areas were known but only 9 occupied. Additional pairs were documented in 1980 and 1984 resulting in 16 breeding areas identified by 1985 but only 15 occupied. In all, 9 breeding areas were added between 1979 and 1990, 7 of those definitely were known to be occupied by new pairs. Highest number of breeding areas and occupancy were recorded in 1988 and 1989. High numbers for these years reflect real increases in numbers of breeding pairs occupying breeding areas and not just increased survey effort.

Productivity

Appendix Table 2 shows reproductive performance of individual pairs of bald eagles in the SW. Overall performance between 1978 and 1990, per pair is shown in Table 16. During survey span of 13 years, a minimum of 193 bald eagles was fledged from 171 breeding attempts, for an overall reproductive output of 0.97 young per occupied breeding area (Table 16). If survey data were more complete, 13 year output would most likely be over 1.0 young fledged per occupied breeding area. Productivity throughout the SW was 1.04 young fledged per occupied nest site with 89 eaglets produced over 5 years between 1985-1989 (Table 17). Productivity of more northern nest sites tended to be lower.

Number of known vs. occupied breeding areas increased from 1978 to 1990 but were not always equivalent (Fig. 9). Figure 10 illustrates annual numbers of active breeding areas and young fledged from 1978 through 1990. In addition to being one of the 2 years with highest number of occupied breeding areas, 1988 had the highest number of young produced (26) and the second highest number of active nests (17). Poorest productivity for SW bald eagles was 1978. Although survey effort and study area familiarity were least in 1978, reproductive performance of known pairs was also low (Fig. 10).

The nesting population of bald eagles in the SW grew 23% to 21 breeding pairs during years of intensive study (1985-1989). Only one breeding area was totally unproductive over 5 years (RKO). One breeding area known prior to 1985 (Slide Lake) was not included in analysis because occupancy was intermittent (Table 16) and the site was considered peripheral to the Snake River flood plain. Another breeding area along the Snake River near South Gate, YNP was not included because survey data were incomplete. Five breeding pairs were added to the population between 1985 and 1989, 4 in 1987 and one in 1988. Two may have been missed on previous surveys (Munger Mtn. & Buffalo Valley) but Third Creek, Elbow and Elk Refuge most probably were initial breeding attempts for those pairs when discovered (Appendix Table 2.). Overall occupancy rate of known breeding areas was 93% over 5 years of study. Occupancy rate in SP was highest at 100% followed by LSR at 95% and ST with 86%.

Productivity (in terms of young fledged per occupied breeding area) was correlated with total young produced ($r = 0.71$, $P = 0.006$). Therefore, productivity of a sample of breeding areas within population units may be representative of reproductive performance within the unit ($y = -3.144 + 18.502x$, where y = total young fledged, x = young fledged per occupied breeding area).

Nesting Phenology

Initiation of nesting activity was later at breeding areas farther north (upstream) in the SW (Table 18). Median egg laying dates were similar in both the LSR and SP. Ranges of egg laying dates were similar in LSR and ST, 18 and 19 days respectively, whereas range of laying dates in SP was large and protracted, spanning 39 days. Hatching was not observed so dates were estimated by adding 32 days (Brown and Amadon 1968) to median egg laying dates.

Median and range of fledging dates were similar among eagles nesting in the LSR and ST. Median fledging date for both areas was in mid-July and ranges were 31 and 32 days (Table 18) with LSR being slightly earlier. In the SP, median fledging dates were nearly 1 month earlier than both LSR and ST but span of fledging dates was largest at 34 days.

Comparison of median fledging dates in different areas of the SW suggests pairs that initiated breeding later in the LSR tended to be more productive, while pairs that initiated earlier were more productive in the SP. No such trends were evident in the ST. Although not seasonally synchronized, span of nesting (egg laying to fledging of young) was similar among all areas in the SW. Longest duration of nesting activity was 155 days in the LSR, followed by ST at 148 days and SP at 145 days.

Age of First Breeding and Adult Turnover

In 3 and possibly 4 instances, age of first breeding was established by noting the initiation year of the breeding area and subsequently determining birth date and origin of the resident male by band number. The breeding adult males from the Sheep Gulch and Elbow breeding areas were siblings, fledged from Ford's nest in 1980. The Sheep Gulch male established a breeding area in 1986 at 6 yrs old, and the Elbow male established a breeding area immediately adjacent to his brother's in 1987 at 7 yrs old. Both breeding areas were within 28 km of the natal nest site.

A subadult male bald eagle banded as a nestling in the SI of eastern Idaho (Antelope Site) in June 1987 was observed associated with another bald eagle of distinctly larger size on the Missouri River in westcentral Montana in summer 1990 (Harmata 1991). In August 1991, he was found associated with the productive Brown's Gulch breeding area on Hauser Lake Montana (an impoundment of the Missouri River). This was the first breeding attempt at this site and the male eagle was 4 years old.

The male at the Elk Lake breeding area in southwestern Montana (CM) was banded at Cliff Lake in the CM on 10 June 1980 and found dead near the inactive Elk Lake nest on 28 September 1989. Observations strongly suggest the breeding area was first occupied in 1986, presumably by the banded male. The Elk Lake nest site was 10 km from the banded male's natal nest on Cliff Lake.

Loss of one member of a resident breeding pair was confirmed at 5 breeding areas by noting absence of a colorbanded eagle, loss of radio signal or recovering a dead eagle. Sheep Gulch, Elbow, Oxbow and Wilcox Point in the SW and Elk Lake in the CM all lost one member during the study (Table 19). In each instance the male was lost. Mean maximum known elapsed time to obtain a replacement mate was 19 weeks and duration appeared related to time in the nesting cycle. The Oxbow female was involved in the early nesting phase (i.e. incubating eggs) when her mate was lost and had the longest replacement time. She also apparently rejected 1 potential mate prior to accepting one in late February or early March following the year of loss. Most brief replacement time was at Wilcox Point during late winter, just prior to egg laying. Female eagles involved in brood rearing or during early winter had intermediate replacement times.

A female may have been replaced in one breeding area. The Elbow breeding area was first occupied in January 1987. The pioneering female exhibited some black in the upper mandible and immature characteristics in head and remige feathers, suggesting she was no more than 4 years old (McCullough 1989). Her most obvious characteristic was a "cross-bill", i.e. her upper mandible was noticeably mal-aligned. The 1987 and 1988 breeding attempts failed. In 1989, the breeding attempt was successful but the resident female did not exhibit a cross-bill. The deformed mandible may have been a temporary condition but more likely the female that pioneered the breeding area was replaced by 1989.

Survival of Juveniles and Immatures

Survival of juvenile and immature bald eagles radio-tagged as nestlings or recent fledglings was high (Table 20). Of 17 bald eagles with radio transmitters that were potentially detectable (i.e. wearing backpack transmitters) or known to be alive the following year, a remarkable 82.5% were alive after their first winter, at least to April following fledging. Immature eagles comprising 58.8% of original cohorts were found alive 2 years after fledging, having survived 2 winters. Nearly 77% of survivors of the first year survived their second winter (Table 21). Percent detected 3 years post-fledging was 50% of those surviving their second winter and 42.9% of those surviving to their first winter. Immature eagles detected 4 years post-fledging (in their 5th year) was a minimal 33.3%. Correcting for probable transmitter failure as indicated by signal characteristics during final locations and subtracting those not detected the previous year, "probable" survival estimates increase (Fig. 11). Regardless of method of calculation, a decrease in survival was evident in the third year and probably reflected actual phenomena.

Eagles fledged in 1987 had the highest first year survival (Table 20) but lower rates for other years probably reflects monitoring effort rather than actual survival. Manpower and emphasis on immatures grew from 1985 to 1987 when effort was greatest but monitoring effort decreased significantly afterwards.

Adult Mortality

Loss of breeding adult male bald eagles appeared high. Males at 5 breeding areas were known to be lost. Circumstances of loss were known at 2; a trap mortality and gunshot wounds (Table 19). Shooting was suspected at 2 others. The nesting pair at Elk Lake, MT was perceived as an impediment to access of a snowmobile route and threats to remove them were rumored. The Wilcox Point male had old wounds resembling gunshot damage on the upper mandible when captured. The Sheep Gulch male perched on obvious perches near Alpine, WY. This eagle too, was perceived as an obstruction to development of a marina on Palisades Reservoir and rumors of threats to "remove the obstruction" were heard, but he may have been replaced by a competing male. No breeding females were known to be lost during study.

Regional Genetic Relationships

Analysis of blood samples (Morizot et al. 1985) from 5 nestling bald eagles produced in 1985 suggested that eagles of GYE population were most closely related to those produced in Oregon and Washington (Morizot pers. comm.).

Home Range of Adult Bald Eagles

Home ranges of bald eagle individuals and pairs determined in the SW are shown in Figure 12. Telemetry and observations indicated all adult eagles nesting along the Snake River were resident throughout the year. Of all studied, only eagles nesting on Jackson Lake left primary breeding areas during winter. Ranges displayed include some seasonal locations away from the primary breeding range in winter for Wilcox Point male, Third Creek male and female. Each left the vicinity of Jackson Lake during mid-winter but Third Creek male and female ranged farther than 125 km. Ranges displayed include winter perches located within the study area but do not include the entire annual range for Third Creek male and female.

Ranges varied by monitoring method, effort, seasons tracked and geographical area. Mean minimum convex polygon area for all bald eagle home ranges delineated in the GYE was 67.19 km^2 (SD = 103.04) but extreme variability in monitoring time and method make comparison of ranges tenuous (Tables 10 & 12). Mean home range polygon area for only radio-tagged adult breeding bald eagles was 85.54 km^2 (SD = 114.3). Including only areas considered primary breeding range in calculations, mean home range polygon size was 47.46 km^2 (SD = 35.02).

Home ranges of 5 bald eagle pairs in LSR monitored by telemetry (Sheep Gulch, Cabin Creek) or visually (Elbow, Dog Creek, Hoback) are shown in Figure 13. Subsequent to radio tracking, the Sheep Gulch and Cabin Creek ranges were reduced by the intrusion of a new pair of bald eagles at the mouth of Bailey Creek. The Elbow pair occupied a new nest December 1986 and effectively truncated adjacent eagle ranges, reducing the Cabin Creek male's range by over half. Mean length of Snake River included in 4 bald eagle home ranges in the LSR prior to the appearance of the Elbow pair was 12.6 km. Including Elbow, mean length dropped to 10.1 km, with Cabin Creek range the smallest and most significantly truncated with only 4 km of river included. Although the Cabin Creek home range had the smallest length of river included, it contained nearly the most total shoreline of all pairs in the LSR (21.03, Table 22). Mean total length of shoreline included in bald eagle home ranges in LSR (Table 22) was 18.78 km.

Home ranges of radio-tagged bald eagles and range boundaries of other bald eagle pairs on the Snake River in SP are shown in Figure 14. As in the LSR, size and shape varied with topography, length of Snake River in the home range and diversity of habitat. Mean length of Snake River included in bald eagle home ranges in SP was 5.1 km.

Figure 15 illustrates home ranges of radio-tagged bald eagles and range boundaries of nonradio-tagged resident bald eagles in ST. Mean number of km of Snake River included in ranges was 9.32. The range of the Third Creek pair included the southern third of Jackson Lake almost exclusively. The Wilcox Point pair ranged over the northern 1/4 of Jackson Lake but also included nearly 8.8 km of the Snake River upstream of the Jackson Lake. Mean length of shoreline of river nesting eagles in ST was 41.6 while total shoreline included in home ranges of all lake nesting eagles monitored was over 63.7 km.

Range boundaries (Figs. 13-15) were not necessarily consistent with breeding area boundaries. Resident adult eagles were observed intruding on adjacent pairs' breeding area several times. These incursions occurred subsequent to observations of adjacent pairs in territorial encounters, where boundaries of breeding areas were evident. Most incursions occurred while territorial adults were not present. On occasions when detected, the intruder vacated the breeding area quickly without combat when detected or approached by the resident eagle.

Multiple regression of home range polygon size of radio-tagged adult breeding bald eagles with time, days and seasons monitored showed strong positive correlation of size with magnitude of monitoring effort (r = 0.852, P = 0.0208). The most significant variable contributing to the regression was overall monitoring time (r = 0.792, P = 0.011). Significance and correlation increased (r = 0.951, P = 0.0014) when only the areas defined by locations in the primary breeding range of the Wilcox male and Third Creek male were included in the home range and the area of the Elbow pairs home range subtracted from total of Cabin Creek. The northern areas of Third Creek male and Wilcox Point male were used in mid and late winter, respectively and were removed from primary breeding ranges and other activity centers temporally and by more than 5 km. This indicated seasonal range use. The most significant variable contributing to the regression was again overall monitoring time (r = 0.952, $P<0.000$). More hours of monitoring over more days and more seasons increased home range size accordingly.

Data manipulation and intuitive processes indicated logit regression analysis as most appropriate for describing home range size and monitoring time relationships. Home range size cannot continue expanding indefinitely with infinite monitoring time, but must level off. Consequently linear regression was not valid. Data were fitted to the logistic curve with the formula:

$$Y = K\big[Bo + B_1(X)/1 + (Bo + B_1(X)\big],$$

where Y = predicted home range polygon size, X = monitoring time (hours). Resultant regression was:

$$Y = 74.62\big[(-4.201 + 0.0132)/1 + (-4.201 + 0.0132)\big], \; (R^2 = 0.752, P<0.001)$$

for regression including only the southern (summer) home range of the Wilcox Point male and

Third Creek male (Fig. 16). Including entire range of the Wilcox Point male and Third Creek male (Fig. 17) resulted in regression form of:

$$Y = 121.4828\Big[(-3.292 + 0.0083)\ (X)/1 + (-3.292 + 0.0083)\Big],\ (R^2 = 0.317,\ P = 0.115).$$

Nesting History, Home Range and Use Areas of Bald Eagles

Bald eagle breeding area descriptions are consistent with those shown in Fig. 3. Descriptions begin with breeding areas in the southwestern SW and progress upstream to, but not including those in YNP. RMS progressed upstream also and resulted in 80 defined. LSR contained RMS 0 to 30 (Fig. 18), SP contained RMS 31 to 50 (Fig. 19), and ST included RMS 51 to 80 (Fig. 20). Observation data for pairs monitored visually are presented in Table 12.

Thayne

The Thayne site has been monitored for production since 1980 but has not been intensively studied. R. L. Skinner (pers. comm.) reported the site productive at least by 1977 and possibly active prior to that date. At least 4 nesting locations are known for this site since 1980. Maximum distance between alternate nests is 1.4 km.

Little is known of the home range of bald eagles nesting at the Thayne site. Adult eagles were observed 1.5 km upstream (south) from the nest on the Salt River and at the confluence with Palisades Reservoir ($\approx$ 15 km north) during the breeding season.

Sheep Gulch

Sheep Gulch breeding area was discovered in 1978 when one adult was observed associated with an old, unrepaired nest in the vicinity of Wolf Creek (see Fig. 21). In 1979, a pair with one member in subadult plumage was observed near a newly constructed nest, also near the confluence of Wolf Creek with the Snake River.

Occupancy and production of the Sheep Gulch pair has been poor. At least 3 nest sites have been used with a maximum distance of 6.1 km between alternate nests. Most recently occupied nest was only a few hundred meters below the USFS Sheep Gulch Boat Landing, where the majority of river floats departed. Strategically located within the home range, the nest site was positioned as far from human activity centers associated with Alpine WY as possible, yet avoiding the vast majority of river traffic associated with Sheep Gulch Boat Landing while still retaining a position immediately adjacent to the Snake River.

When captured, the resident male was banded indicating he had fledged from the Ford's site, 26 km north on the Snake River (Fig. 3). He included portions of the Snake and Grey's River, a large delta area at the confluence and part of Palisades Reservoir in the range (Fig. 21). Sheep Gulch male's range covered 10 RMS (0-9) including white water and long, narrow stretches of Snake River. Many small peripheral streams enter the river within the range and surrounding topography displayed the most relief of any range studied.

Over 75% of total shoreline included in Sheep Gulch Male's home range was River shoreline (Table 22). Lake shoreline of Palisades Reservoir included was mostly at the confluence of the Snake and Grey's River. Most of 38 locations of the Sheep Gulch male were associated with his mate and many with the progeny of the year until autumn; home range of the Sheep Gulch female was effectively the same as the male. Many of the 38 perch locations detected were habitually used. The Sheep Gulch male disappeared in December 1986. Soon after, a subadult male was observed on perches commonly used by the Sheep Gulch male and associated with a large eagle, presumably the Sheep Gulch female. By May, 1987 no eagles were observed within range, and the nest has not been occupied - indicating the breeding area may have been abandoned.

Use areas of the Sheep Gulch male are shown in Appendix Figures 1 and 2. Radio-tracking covered PF, F and W seasons and most locations were near the mouth of the Snake River near Alpine WY (Appendix Fig. 1). Prior to radio-tracking of the Sheep Gulch male however, adult bald eagles were observed infrequently near alternate nest sites at the mouth of Wolf Creek, 5 to 6 km upstream of the Sheep Gulch nest site (Appendix Fig. 2). Although these observations may have been of wintering or migrant eagles, as spring progressed, eagles observed at the mouth of Wolf Creek were probably members of the Sheep Gulch pair, considering subsequent home range delineation which included the mouth of Wolf Creek during radio-tracking. Use of the Wolf Creek area was probably more common during EN and LN seasons than radio-tracking indicated. After their eaglet fledged food availability may have been greater in the lacustrine portion of the Snake River near Palisades Reservoir (Fig. 21) and use shifted accordingly. Also coincident with the initiation of radio-tracking was a dramatic increase in float traffic upstream of the nest site.

Most of Palisades Reservoir included in the Sheep Gulch home range was associated with much human activity. However, specific eagle use areas (Appendix Fig. 1) were in areas that provided physical barriers and visual buffers from most human activity. Large mud flats used by the pair were not visually screened but did provide extensive views that prevented surprise human encounters or early detection of human approach.

Other areas of Palisades Reservoir may not have been available to the Sheep Gulch pair. These areas were farther from the nest site and used by other nesting pairs of eagles on the Idaho (west) side of the Reservoir.

Even though the majority of use was near Palisades Reservoir, the Sheep Gulch male and female would make daily forays upstream of the nest. These trips and use of areas upstream occurred almost exclusively in late afternoon, when recreational activity was much reduced or absent during the tourist season. Night roosts were most often located upstream of the nest. Use upstream gradually became earlier in the day as autumn progressed and river traffic subsided.

Elbow

Elbow pair first occupied a nest site and breeding area in January 1986. The female exhibited subadult characteristics in the mandibles (brown streaking) and the male was banded. First nesting attempt for the pair occurred during 1987 in a nest constructed and used by ospreys the year before. Three nest sites have been used with the greatest distance between alternates being 0.9 km. The most recently occupied nest was only 50 m from a campground heavily used by humans for many years prior to appearance of nesting eagles.

Bald eagles associated with the Elbow site were monitored visually and only 24 individual perches for both male and female were detected. Size of the home range polygon is absolute minimum (Fig. 22). Lack of telemetry data and difficulty of observation precluded accurate description of the home range, but boundaries on the Snake River were probably accurate within 1 km. Range included 6 RMS (10-15) with the smallest amount of total shoreline of all eagles in the LSR and no lake shoreline. The entire Elbow range was within the Cabin Creek Male's home range delineated prior to the initiation of the Elbow breeding area. Curiously, the Cabin Creek Male was observed (colorband) well within the range of the Elbow pair at least 3 times after initiation of the Elbow breeding area. Although he was within view of the Elbow pair, no agonistic behavior was observed. Agonistic behavior between adult bald eagles was observed at the western (downstream) boundary with the Sheep Gulch range however, well after confirmed occupation of the Elbow breeding area. The Elbow Male was eventually determined by band number to be a sibling of the Sheep Gulch Male.

The Elbow pair used portions of the Snake River directly in front of Elbow campground intensely (Appendix Fig. 3). Their use area included the mouth of Bailey Creek; a cutthroat trout (*Oncorhynchus clarki bouvieri*) spawning tributary of the Snake River (J. Erickson, WGFD, pers. comm.). Although observations were heavily biased towards the nest site, time either or both eagles were absent from view was minimal, indicating that the area was indeed highly used by the pair. Angling in the section of the Snake River included in the home range of the Elbow pair is considered good by local fishing outfitters (B. O'Neil, Mad River Expeditions, Jackson WY). One of only 2 river fords exists just opposite the nest site at the Elbow. Fords are often indicative of shallow runs and riffles; conditions conducive to increased availability of fish to eagles. The pair fledged 2 young in both 1988 and 1989, despite the male being lost during the LN season in 1989.

Cabin Creek

Records of bald eagle occupancy of Cabin Creek nest sites date back to the 1940's (B. Hepworth pers. comm.). Five nesting locations were known to have been used and 2 nests are separated by 2.2 km at the extremes.

Movements of the Cabin Creek pair were monitored visually by WGFD (1978-1982). Home range polygon developed from these observations is presented in Figure 23 and does not include areas below the Elbow. The smaller home range indicated by these early observations was probably a result of less intensive study over a shorter duration of the breeding season and lack of ability to follow unmarked eagles along the more heavily timbered corridor of the Snake River downstream of Elbow.

During radio tracking, home range polygon included over 45 km^2, 12 RMS and 44 km of Snake River and island shoreline (Fig. 24 & Table 22). After initiation of the Elbow breeding area and shedding of the tail-mounted transmitter by the Cabin Creek Male, observations suggested that the number of RMS included in the home range was reduced by 2/3, to 4. Lack of telemetry data post-Elbow initiation prevented delineation of home range polygon for Cabin Creek thereafter but most likely, range size was probably reduced by about 2/3 and Snake River shoreline included reduced by about ½. Consequently, home range polygon size and length of shoreline included may have approached 22.29 km^2 and 21.03 km, respectively.

Use areas of the Cabin Creek male were defined by 125 individual perches and are shown in Appendix Figures 4 and 5. High use areas were mostly in the vicinity of the nest site and northern boundary of the breeding area, but also included areas near the mouth of Bailey Creek prior to the initiation of the Elbow breeding area. Low use areas were mostly in the extreme downstream portion of the range, in RMSs with lower habitat diversity. High use areas off river were on steep slopes over looking the nest and used primarily for loafing and feeding. The nest and use areas were effectively insulated from human activity by private land, where access was strictly controlled. The Cabin Creek range straddled an elk migration route and resident eagles were observed feeding on elk carcasses well into July some years. Most night roost sites used during EN and LN seasons were in the nest proper or on branches of the nest tree next to the nest. In other seasons, roosts were scattered throughout high use areas. The Cabin Creek breeding area is the most productive in the GYE. Young were fledged every year between 1978 and 1990 except 1983. The pair fledged 2 young the year of intensive study.

Dog Creek

Bald eagles nested in the Dog Creek breeding area long before being recorded by the WGFD in 1979 (J. Turner pers. comm.). Nests have been constructed in at least 5 different trees and 4 nests were within 0.2 km of each other. One alternate nest was centrally located on the western edge of the home range and separated from the most distant alternate nest by 1.5 km.

Dog Creek range was defined by 57 perches of both male and female discovered during monitoring over an entire annual cycle (EN-W seasons, Table 12). Home range polygon was second smallest of those in the LSR (Fig. 25) with only 4 RMS (19-22) included. However, nearly 19 km of river and island shoreline included (Table 22) was equal to or more than that contained in most bald eagle home range polygons in the LSR. Still, resident eagles appeared to spend more time farther away from the Snake River than adjacent pairs. The Snake River flood plain peripheral to the Dog Creek range was wider, flatter and included more creeks, ponds and springs than any other range in the LSR. An elk feed ground was also included in the Dog Creek pair's range and the seasonal migration route traversed the River close to the nest. Elk drowned during River crossing may provide food in the form of carcasses periodically. The Snake River was more braided and sinuous and peripheral benchland contained higher ground squirrel (*Spermophilus spp.*) populations than any other bald eagle range in the LSR. More islands were contained in the Dog Creek pair's home range than any other in the LSR. Diversity of habitat increased with islands hence the range included more riffles, runs, pools and shoreline than most all other eagle ranges in the LSR.

Visual observations (1979-81) prior to intensive study resulted in a similar home range polygon (Fig. 23). Use of the area upstream from Astoria, was not recorded during early study but the developed area around Astoria was avoided in both studies. The nest site and most high use areas were protected from close human activity by the Snake River and surrounding private land. Trespass on the R bar D ranch on which both the Cabin Creek and Dog Creek eagles nested, was strictly controlled and rarely granted.

Delineation of use areas for the Dog Creek pair may have been strongly influenced by observer biases associated with monitoring unmarked eagles. Dog Creek eagles spent more time out of observer view than other eagles in the LSR, especially during autumn. This indicates intensity of use of areas on the river may be lower than that determined by observation (Appendix Fig. 6). All roost sites detected were in the nest, nest tree or nest stand. The pair fledged 4 young during the 2 years of intensive observation (1985-1986).

Hoback

Bald eagle nesting at the Hoback site was first recorded in 1985. No alternate nests are known. Prior to 1985, red-tailed hawks (*Buteo jamaicencis*) were associated with the nest site. The nest was obvious from highway 285 and an undeveloped campground directly across river. Local residents were aware of the site and generally interested in the eagles.

Hoback home range polygon (Fig. 26) was determined by 86 visual locations including male and female discovered during monitoring over an entire annual cycle (EN to W seasons, Table 12). Hoback range had the most river (after initiation of Elbow breeding area) with 15.3

km included in 9 RMS (22-30), but had fewest islands and peripheral streams per RMS. Home range boundary included only RMS 22-26 because locations in RMS 27-30 were few, imprecise and may have included members of the adjacent Munger Mountain pair nesting immediately upstream. However, the male was known to fly up river to South Park Bridge (RMS 30). The Snake River also was mostly straight with no side channels or sloughs in the home range polygon as indicated by relatively low proportion of Snake River shoreline (16.4 km: Table 22) to total river miles. The range did include the Hoback River although few locations upstream of the confluence with the Snake were noted. Both members were observed flying over ridgelines and hills well east of the Snake River (and home range boundary, Fig. 26). Actual home range was therefore much larger than indicated by home range polygon.

Use areas of the Hoback eagles are shown in Appendix Figure 7 and appear to be carefully distributed between dwellings and housing developments. Use area delineation may have been influenced by difficulty of maintaining visual contact of unmarked eagles, but relative intensities shown are probably fairly accurate. The primary high use area was in the vicinity of the nest, similar to patterns exhibited by the radio-tagged Cabin Creek Male. Apparently highly suitable, insulated perch sites were not used because surrounding habitat was poor. Conversely seemingly high quality habitat along the Snake River was not used due to the absence of perches or proximity of human activity centers. Certainly use of some areas off the Snake River flood plain escaped detection, much like the situation of the adjacent Dog Creek pair. Curiously, little use of the Hoback River was noted but overland flight paths eastward from the nest may have ended several km upstream on the Hoback River and consequently some use areas were most likely undetected. The character of the Hoback River was considerably different from the Snake. Few cottonwoods were present in areas not impacted by houses or high human activity levels. Many meadows extended to river's edge, resulting in intermittent availability of perches. Although high and medium use areas included recreational, housing and commercial developments, few people seemed to notice the eagles. Timing of use varied throughout the day and Hoback eagles did not appear to modify their movements in response to normal human activity levels, which were subjectively low. The Hoback pair fledged 1 young during 2 years of intensive observation.

Munger Mountain

Munger Mountain breeding area was first recorded occupied by bald eagles in 1987. Size of the nest indicated the site may have been occupied previously but WGFD eagle surveys (1980-1984) specifically concentrated on this area as a highly probably site for occupancy with negative results. Regardless, the site was probably not occupied prior to 1985. Two nest sites were used by the pair and are separated by 0.3 km.

Range boundaries of the Munger Mountain bald eagle pair (Fig. 14) were determined through direct observation during banding of nestlings, radio tracking of immatures, and capture of other eagles during PF, F and EN seasons. Boundaries are minimums but probably include most of the actual range on the Snake River. Munger Mountain adults included 3 RMS in the home range (RMS 31-33), the fewest of any bald eagle range on the Snake River in Wyoming. Range of eagles nesting at the Munger Mountain site was apparently compressed by adjacent eagle pairs. Perches along the Snake River were concentrated into highly disturbed but high quality habitat. Recreational use of the River and shore opposite the nest site is excessive and long term, often present from 15 May to 15 November. However, adult eagles were observed leaving the Snake River flying due east towards Game Creek, disappearing behind low ridges east of the Snake River flood plain. Conversations with residents of Game Creek revealed observations of adult bald eagles perched near ponds created by beaver (*Caster canadensis*) along Game Creek in summer. Obviously not migrants, those eagles were probably adults from the Munger Mountain site, at least 6 km to the west.

Residents also observed adult bald eagles during summer along Flat Creek, north and northeast of the Munger Mountain nest site. Those eagles were most likely Munger Mountain adults because movements of the adjacent pair were relatively restricted to the west (see Butler Creek below). Use of Game Creek and Fish Creek would at least triple the size of the range detected from observations along the Snake River (Appendix Fig. 8). These sorties away from the River almost seem necessary, considering apparent lack of access to high quality habitat on the Snake River due to excessive human presence and activity. Three young were fledged in the Munger Mountain breeding area between 1987 and 1988.

Butler Creek

The Butler Creek pair was first located in 1980 on the east side of the Snake River in a nest built and formerly used by osprey. Five alternate nests were used between 1980 and 1990; although 3 nest trees blew down between 1980 and 1983. Since 1983, the pair has continued to use the same nest on the west side of the river. The greatest distance between known alternates is 1.8 km. The most commonly and recently used nest was isolated from most human activity by private land.

Home range of the Butler Creek bald eagle pair included 21 locations of the radio-tagged adult female and 11 additional sightings of the adult male (Fig. 27). Only one location of the male was used for delineation of the home range. Resultant home range was smallest defined for any radio-tagged eagle in the GYE. Monitoring period was shortest and occurred during the EN and LN seasons, a time when female eagles would be especially attentive and restricted to the nest. Visual locations of the male were impeded by excessive monitoring distance and vegetative screening. The Butler Creek pair fledged 2 young the year of radio-tagging.

Butler Creek home range included 4 RMS (33-36), but total length of shoreline included was consistent with 4 other eagle pairs in the LSR (Table 22). Home range boundary (at least river boundary) was probably most representative of any pair studied because during incidental observations both before and after radio tagging, at least one adult eagle was visible during any time period, weather or season. WGFD visual observations (1980-83) resulted in a home range polygon (Fig. 22) similar to that delineated by this study.

Six use areas were identified for the Butler Creek female from 21 individual perches; 2 areas each of high, medium and low use (Appendix Fig. 9). All high use areas included the Snake River as did the largest medium use area. Northern medium use area on the east side of the Snake River was associated with Blue Crane Creek and other spring creeks. Creeks in SP are especially productive, providing good spawning habitat for fish and nesting habitat for waterfowl. Use areas may have been artificially concentrated around the nest site due to short monitoring time over primarily EN season. The female was brooding 2 nestlings when captured and shed the transmitter in mid-June. Her tenacity to the active nest was undoubtedly a function of maternal instincts and care and feeding of the young. Medium and low use perches located in the south central portion of the range were associated with an old nest. The nest was in a large Douglas-fir (*Pseudotsuga menziesii*) on a northeast facing slope and was probably built by eagles. Western low use areas were associated with perches in Douglas fir situated on a slope with an eastern aspect. These were used when an adult eagle (probably the Butler Creek male) was observed foraging on small fish stranded in irrigation ditches in an alfalfa field below. Eleven individual perches were detected for the Butler Creek male. Only 3 use areas were defined for the Butler Creek male (Appendix Fig. 10). Lack of observability of the male away from the nest site affected detectability of use areas, of which there certainly were more.

Gill's

WGFD records first document the Gill site in 1981 but several commercial floaters reported the site to be active previously. Only one nest has been used (1981-90). Like Butler Creek, the nest site and most foraging areas were totally insulated by private land on which access, especially to eagle researchers, was strictly forbidden.

Bald eagles nesting at the Gill's site were least observed. Vegetation, topography and lack of access to portions of the home range prevented adequate viewing of resident adults. Range boundaries along the Snake River are fairly representative, however, as indicated by of observations of radio-tagged Butler Creek female immediately downstream and Ford's pair immediately upstream (Fig. 14). Eagles associated with Gill's site included only 3 RMS (36-38). One trap day within documented range produced a 3-year-old female eagle, obviously not one of the resident adults. Use area and perches recorded for the Gill's pair are shown in Appendix Figure 11. Visual locations in 1981 produced a home range polygon shown in Figure 28 indicating the importance of the same RMS as identified in this study.

Ford's

WGFD records indicate bald eagles were known to occupy nests in Ford's breeding area as early as 1978 but local residents reported a pair occupied the site for many years prior. Four nesting locations were used between 1978 and 1990. Greatest distance between alternate nests was 1.9 km. As housing developments expanded to the south on the east side of the Snake River, nesting activity also moved south.

Ford's pair was fairly elusive and difficult to observe. Southern range boundary is quite representative (Fig. 14) when considered with observations of eagles associated with Gill's site. The northern range boundary was somewhat less distinct but observations of eagles identified as the Ford's pair did not occur north of the Wilson Bridge (RMS 42). Observations were comprehensive enough to indicate 5 RMS (38-42) were included in the range along the Snake River. Movements of a radio-tagged juvenile produced at Ford's site in 1987 suggest the adult pair's home range may extend at least 13 km west of the nest, especially during autumn. As with other bald eagle pairs nesting along the Snake River, sightings of adults along the river near the nest site were least frequent in autumn. Timing suggests eagles associated with Ford's site may have been exploiting wetlands in South Park or near Wilson WY or viscera piles left by elk hunters in higher elevations away from the river. If so, home range of the Ford's pair would have been quite large, extending several km off river. The portion of the west side of the River that included a dike with an access road open to the public was clearly avoided by the Ford's pair. Human activity on the dike road was year round but levels of human use were higher in summer.

Perch use area of adults are displayed (Appendix Fig. 12) and indicate the southern half of the home range was more heavily used. The 1986-87 data indicate a home range similar to that delineated by previous observations by WGFD in 1978-82 (Fig. 28).

Elk Refuge

First indications of occupancy of the Elk Refuge site was in 1988 (L. Craighead pers. comm.) when one adult was seen perched next to a large nest. First confirmed activity (and production) was in 1989 (P. Harmata pers. comm.). Consequently, little time was available to observe the pair. Observations by GTNP, National Elk Refuge (NER) and WGFD personnel suggest the home range included most of the NER, primarily Flat Creek and may have extended as far east as Flat Creek Lake (16 km east). There were no indications the Elk Refuge pair included the Snake River in the home range. However, movements of a radio-tagged adult bald eagle which frequented NER in winter 1986-87 suggest the Snake River may have been included in the Elk Refuge pair's range especially if the radio-tagged eagle was the male associated with the Elk Refuge nest. If not, high quality abundant food sources were available year round within sight of the nest and inclusion of the Snake River in the home range may not have been necessary. Very high numbers of waterfowl were associated with Flat Creek and Flat Creek ponds within 1 km of the nest. The USFWS fish hatchery in NER was also within 1 km while NER feedground provided abundant, fresh ungulate carcasses throughout winter.

Slide Lake

Bald eagle nesting at Slide Lake was first recorded in 1976 (F. Christiansen pers. comm.). At least 4 nests with maximum distance of 1.2 km between were constructed by eagles to 1990. Since 1979, the site has shown a high rate of nesting failures, adult turnover and low occupancy rates. The site was not observed during this study and virtually nothing is known of the home range. Adult bald eagles have been observed at Lower Slide Lake and up the Gros Ventre River as far east as Upper Slide Lake, 15 km from the nest site.

Gros Ventre

Gros Ventre site was occupied prior to 1978 (R. Wood pers. comm.). At least 6 alternate nests have been located with maximum distance of 0.9 km between alternates.

Visual locations of the pair were obtained by WGFD in 1980 and 1981. Resultant home range polygon is shown in Figure 29. Observations indicate that eagle activity was focused at the confluence of the Gros Ventre and Snake Rivers, extending 2.0 km up the Gros Ventre and 4.0 km up the Snake Rivers.

Bald eagles associated with the Gros Ventre breeding area were not included in intensive observation in this study (Appendix Fig. 13). However, the hiatus of habitat between the Ford's and Moose home ranges suggested 7 RMS (42-48) were available to the pair. Eagles associated with Gros Ventre site were observed as far as 6.8 km south of the nest and as far as 4.8 km north.

Solitude

Solitude site was known prior to 1978 when monitoring of production was initiated (Alt 1980). At least 4 young fledged between 1978 and 1980. Development of Solitude housing subdivision was started in 1980 and the site abandoned by 1981. Movement of eagles associated with Solitude were not observed prior to 1981. Based on observations of the Gros Ventre pair (1980-81), it is doubtful that the home range of the Solitude pair extended more than 3.5 km south of the nest. Bald eagles seen at Phelps Lake (1978-80) suggest that the Solitude pair included the lake ($\approx$4 km NW) in their home range. Northern boundary limits were undiscernible and relationship with the next pair of breeding eagles upstream (Moose) is confusing. Whether eagles associated with Moose site are those previously associated with Solitude site or whether observations represent 2 pairs is unclear. Subjective impressions and incomplete data support both hypotheses, depending on perspective.

Moose

Unsuccessful nesting attempts by bald eagles were observed near Moose, WY in the early 1970's (R. Wood pers. comm.). Intensive helicopter surveys (1978-79) and fix-winged aircraft (1978-82) failed to locate a nest. A nesting pair was located during aerial surveys in 1983. Eagles appeared to be using a relatively small nest, either recently constructed by eagles or previously constructed by red-tailed hawks.

Adult bald eagles associated with Moose nest site included at least 8 RMS (48-55) in their home range. Southern range boundary along the Snake River (Fig. 14) was determined somewhat subjectively due to paucity of observations in that area and confusing relationship with Solitude pair. Northern range boundary (Fig. 15) was quite accurate due to observations of territorial encounters among adults of the Moose pair and adjacent Schwabacher pair upstream to the north.

Three nest locations were used by the Moose pair from 1983 to 1990 and maximum distance between nests was 1.5 km. Closest alternate was 2.4 km upstream from the Solitude nest; while the nest used in 1983 was 3.4 km distant from the Solitude nest. Distances suggest Solitude and Moose were 2 different nesting pairs but timing could also indicate one pair moving from one range to another, shifting of range boundaries or turnover in the pair (Flath et al. 1991).

Schwabacher

The Schwabacher site was first documented in 1956 (Huser 1968). Since 1978 at least 5 nesting locations have been used. Only 0.6 km separates the 2 distant alternates. All nesting locations are in the northeast quarter of the home range.

Home range of the Schwabacher male was well documented during over 2 years of radio tracking (Fig. 30). The Schwabacher male included 9 RMS (56-64) in his home range. He also included portions of Jenny, Bradley and Taggart Lakes and Cottonwood Creek in the home range. Total amount of shoreline included in the home range was second largest of eagles nesting on the Snake River (Table 22) and consistent with a general trend of increasing amount of shoreline included in ranges located successively upstream along the Snake River. Several territorial encounters between the Schwabacher adult pair, the Triangle X pair to the north and Moose pair to the south were seen, delineating definitive boundaries of the home range along the Snake River.

There were 244 individual perches used by the Schwabacher male from 7 July 1987 (day of initial capture) through 30 August 1989. In 1987, 191 perches were located and 53 were found in 1989. Perches were dispersed along the Snake River from Snake River Overlook in GTNP to Moose WY, along Cottonwood Creek from Jenny Lake downstream to south end of Lupine Meadows and Bradley and Taggart Lakes areas in GTNP. Use areas of the Schwabacher male were well dispersed throughout the home range (Appendix Figs. 14-22). During EN, LN and early PF seasons he used areas along the Snake River primarily around the nest site to 3.2 km downstream and up to the northern boundary of the breeding area near Deadmans Bar (Appendix Figs. 15-17). Use areas shifted abruptly soon after progeny left the nest and were subsequently centered at Jenny, Taggart and Bradley Lakes (Appendix Figs. 18 & 19). Primary use continued at these lakes and upper portions of Cottonwood Creek through PF and most of F seasons, then returning to the Snake River in the vicinity of the nest site Appendix Fig . 20). In late F, there was another abrupt shift in area use returning to the head of Cottonwood Creek at the south end of Jenny Lake (Appendix Fig. 21). As many as 11 individual bald eagles of varying age were seen here, including #099 and #393 (fledglings from

2 years at Third Creek). Use of Cottonwood Creek coincided with spawning mountain whitefish (*Prosopium williamsonii*) as well as the closure of Jenny Lake Campground and Jenny Lake Ranger Station, 2 km south of the campground. In mid-December, he moved back to the Snake River, frequenting primarily the area near Ditch Creek outlet where wintering waterfowl were evident (appendix Fig. 22). No foraging attempts were observed due to visual obstructions. Closer observation would have disturbed normal behavior. Six eagles fledged in the Schwabacher breeding area during the 3 years of intensive study.

Triangle X

Bald eagles in the Triangle X breeding area were first observed constructing a nest in 1984. Initial observations were believed to represent the first nesting attempt in this breeding area (J. Turner pers. comm.). Nesting occurred at locations 0.7 km apart between 1984 and 1990. Triangle X included RMSs 64-69 in the River range. Virtually nothing is known of the home range of Triangle X pair save the southern boundary with Schwabacher pair. Range boundary between Triangle X and Schwabacher pair (Fig. 15) was precise and defined by 4 observations of agonistic encounters at territorial limits. Range boundary between Triangle X and adjacent RKO pair to the north was approximated and based on fewer than 10 observations of local adult eagles. One high use area was identified to be the steep slope at the southern extent of the breeding area, below Snake River Overlook. Although close to human activity concentrations at the Overlook, perches were visually and physically insulated from human activity.

RKO

Eagles associated with RKO site were least observed in ST. Huser (1968) suggests eagles were associated with the RKO site as early as 1956. Range boundaries among RKO and Triangle X, Oxbow and Buffalo Fork are obscure and nothing more than best guesses based on incidental locations of a few unidentified adults and movements of the radio-tagged Oxbow pair. As a result, RKO pair was considered to include RMSs 69-74 in the River range.

Oxbow

Nesting bald eagles were associated with the Oxbow site as early as the mid 1960's (Alt 1980). At least 6 nest sites, 3.2 km apart at extremes were used between 1978 and 1990. All but one were within 100 m of the Snake River.

Radio tracking of the Oxbow male was short because the eagle was shot 1 month after radio tagging. When recovered, the Oxbow male was alive, shot through the upper mandible. He was stabilized and sent to the Raptor Rehabilitation Center at the University of Minnesota where he was evaluated and euthanized. During the short period of tracking, his range included 4 RMS (76-79) and portions of Emma Matilda and Two Ocean Lakes (Fig. 31), but range size was probably at least double recorded. Home range polygon does not reflect inclusion of lakes because of imprecise locations of perches, but he was known to fly over both. Accordingly, shoreline calculations do not include lakes or islands in lakes (Table 22). Use of lakes was also during periods of ice cover, and attraction was probably to ungulate carcasses and not waterfowl or fish.

Home range of the Oxbow female was probably most representative of the pair (Fig. 32) due to extensive and intensive monitoring time (Table 10). Home range size and shoreline included (Table 22) are more consistent with eagles that experienced similar monitoring effort.

Although Oxbow female included portions of Jackson Lake which were also contained in the ranges of the Third Creek pair, no territorial encounters were observed.

Radio-tracking of the Oxbow male covered only 4 weeks of the EN season before he was shot on 14 April 1987. During this time, 31 perches included in 5 use areas around the nest site, the Oxbow and Pacific Creek were delineated (Appendix Fig. 23). He also used areas around Emma Matilda and Two Ocean Lakes, presumably exploiting carcasses for at this time, both were frozen.

There were 177 individual perches in 7 areas used by the Oxbow female bald eagle from 17 August 1988 (day of capture) through 30 August 1989, dispersed primarily along the Snake River from Jackson Lake Dam to Moran Jct. WY, with a few perches in Spalding and Catholic Bays on Jackson Lake (Appendix Fig. 24). Observations prior to capture indicated that during EN and LN seasons, the Oxbow female concentrated her activity around the nest and downstream to Cattleman's Bridge. After eaglets fledged (PF season), she moved farther downstream to the Oxbow bend area but also used portions of Jackson Lake.

After capture in August when young had fledged, the Oxbow female began frequenting the Oxbow Bend area and the Snake River (2 km downstream) where mallards (*Anas platyrhyncos*), common mergansers (*Mergus merganser*) and abundant schools of suckers were present (Appendix Fig. 25). In late PF and F seasons, the Oxbow female began using the Snake River near Pacific Creek outlet and across from the boat launch near Moran Jct (Appendix Fig. 26). Waterfowl frequented this area and foraging attempts on fish by the Oxbow female were observed. She continued to use the Oxbow area but also the Snake River 1 km downstream of Jackson Lake Dam. She ventured to Uhl Hill in December after the elk hunt, where she was observed feeding on viscera piles left by hunters (Appendix Fig. 27). During EN season, use areas were restricted to the Snake River between Jackson Lake Dam and the mouth of Pacific Creek (Appendix Fig. 28) as waterfowl again congregated in these areas. Use areas were even fewer and more concentrated during the LN season, presumably due to affinity to nestlings (Appendix Fig. 29).

Third Creek

Bald eagle nesting at Third Creek was discovered when a radio-tagged adult female was found incubating there on 27 March 1987. She had been captured and radio-tagged in the LSR (in the Dog Creek home range) in December 1986. Although bald eagles had been seen frequenting the south end of Jackson Lake for several years (R. Wood pers. comm.), observed nesting activity probably represented the first attempt at that site. The nest was located within easy access of spring creeks which opened early in the season, concentrating both migrant and nesting waterfowl. It was situated at least 2.4 km from major centers of human activity, i.e. Jackson Lake Lodge (3.2 km), Jackson Lake Safety Dam (2.4 km) and Signal Mountain Lodge (3.3 km).

Home range polygon area of the Third Creek male was over 70 km (Fig. 33). Area did not include country covered during seasonal movements away from Jackson Lake (>5 km) or while wintering near Gardiner, Montana, 126.32 km due north of the nest site. Home range covered virtually the entire southern half of Jackson Lake during the breeding season. Range included varying lengths of shoreline (Table 22) as monitoring covered periods of fluctuating water levels on Jackson Lake. Maximum shoreline included was during periods of medium water level.

Home range polygon of the Third Creek female was almost entirely within her mate's (Fig. 34). Total range size and length of shoreline included was a reflection of monitoring time because subsequent to shedding the transmitter, she was seen with her mate at the western and northern extents of his home range. Therefore, actual range and shoreline included are probably identical to those of the Third Creek male.

An adult bald eagle wearing a colorband of the same color/leg combination as the Third Creek female was seen south of Pinedale WY in winter of 1988. This and the fact that the Third Creek male did not appear to be associated with another larger adult bald eagle away from Jackson Lake in winter suggests the pair left the breeding area and wintered separately.

Use areas were defined for the Third Creek male bald eagle for all seasons over a 2 year period (1988-1989). Monitoring covered LN, PF, F and W seasons in 1988 and W, EN, LN, and a portion PF seasons in 1989.

Of 39 distinct use areas defined by 220 individual perches of the Third Creek male (Appendix Figs. 30-39), only 8 were not associated with Jackson Lake. Thirty-five were associated with the southern 1/3 of Jackson Lake (Appendix Fig. 30). Only 7 use areas were more than 5 km from shoreline, and all were used during mid winter (January-February 1988-89). Early winter use areas were associated with water that iced over late and thermal areas (Appendix Fig. 35). On 15 December 1988, the Third Creek male left the vicinity of Jackson Lake.

Subsequent efforts to locate the Third Creek male after leaving Jackson Lake were constantly thwarted by bad weather, but he was located for brief periods along the Firehole River near Old Faithful in YNP and the Flagg Ranch/Huckleberry Hot Springs vicinity (Appendix Fig. 36). He was next located near Gardiner, Montana, in mid-January 1989. During this time a bison (*Bison bison*) hunt and a special late-season elk hunt occurred in Montana (15 December-15 February). During 4 visits to the Gardiner area in late January and early February, the Third Creek male was located by triangulation but no visuals were obtained. Locations were associated with many (>25) wintering bald eagles and scores of ravens along Bear Creek and Yellowstone River, as well as viscera piles around Decker Flats and the benchland southwest of Jardine, Montana.

By mid-February, the Third Creek male had returned to GTNP. Jackson Lake was ice covered and the male divided his time primarily between Pilgrim Creek, below Pilgrim Peak and the outlet of Two Ocean Lake along Two Ocean Creek (Appendix Figs. 35 & 37). Although remoteness and snow cover prohibited visual locations of the male when he was in these areas, moose (*Alces alces*) wintered along Two Ocean Creek (R. Wood pers. comm.) and he probably fed on readily available winter-killed ungulate carcasses in both river valleys. He also was located throughout the southern part of Jackson Lake and occasionally in the Polecat Hot Springs vicinity near the south entrance to YNP. When the pair began nesting in late March, ice on Jackson Lake was receding and absent from creeks in the willow flats area. Waterfowl were beginning to concentrate in large numbers on pools of open water and along creeks. The male spent most of his time concentrated in such areas near the nest (Appendix Fig. 37 & 38).

In late May 1989, the Third Creek nest failed and both adults left the nest area. The male was located mostly in Moran and Bearpaw Bays throughout June until late July when tracking ceased (Appendix Fig. 39). Water level peaked in early July, filling Moran and Bearpaw Bays, permitting motorcraft access to once inaccessible portions of the Bays. Although the pair continued to frequent the Bays, perches used were farther inland.

Use pattern shifts were evident among seasons and years. In 1988, the Third Creek pair produced 2 young but failed during late incubation (EN season) in 1989. Water level was held relatively constant at medium level through early and late nesting seasons in 1988 but fluctuated greatly in 1989, being low in EN and high in LN. Fluctuations were associated with construction at Jackson Lake Dam and filling of Jackson Lake post construction in April 1989. Distribution of use areas during LN differed between years.

LN use areas were associated primarily with the nest site in 1988 but were more dispersed in 1989 (c.f. Appendix Figs. 31 & 38). Behavioral affinity to an active nest site, proximity of wintering and migrating waterfowl on Second and Third Creeks and potential availability of large ungulate carrion on Willow Flats probably focused the Third Creek male's activity during LN 1988. Reduced affinity to the failed nest may have resulted in the Third Creek male ranging more widely in the 1989 LN season (Appendix Fig. 39). PF season 1988 spanned 2 water levels, medium in the first half (Appendix Fig. 32) and low during the second (Appendix Fig. 33). Distribution of use areas shows less affinity to the nest site and apparent responses to local availability of prey. Half Moon Bay became sequestered from the main lake in mid PF season 1988 and continued to recede. Many great blue herons (*Ardea herodias*) and white pelicans (*Pelecanus erythrorhynchos*) were seen concentrated there while tracking the Third Creek male who also focused his activities there (Appendix Fig. 33). All 3 species presumably were concentrating on readily available fish due to receding water levels. During F season, the Third Creek male's use areas became even more dispersed (Appendix Fig. 34).

Most (48.5%) of 35 use areas associated with Jackson Lake were considered at medium intensity use (Appendix Fig. 30). Only 25% (9) were considered high use, the majority (5) located on small islands and points protruding into the lake commanding extensive views of prime foraging habitat. The largest area of high intensity use included the nest site proper (Appendix Fig. 30). Seven or 20% of use areas were considered low use and most located off Jackson Lake. Most low use areas were used during winter or early nesting seasons and were associated with areas of concentrated ungulate winter mortality.

Intensive monitoring of the Third Creek female bald eagle was initiated on 27 March 1987 and ended on 8 August 1987, during which 108 individual perches were detected. Accordingly, only a portion of the EN season, all of LN season and 1 week of PF season were observed. Use areas therefore, were defined for the Third Creek female only for EN and LN seasons. However prior to intensive monitoring, the Third Creek female was located in winter 1986 in the LSR (captured there), on Shadow Mountain in eastern GTNP and on the Snake River the Schwabacher breeding area. Like her mate, she apparently left her breeding area and wintered independent from him.

Nine use areas were defined for the Third Creek female for EN and LN seasons 1987 (Appendix Fig. 40). Ignoring time spent on the nest platform proper, only one area was considered high use. The majority (6) were defined as medium use, the largest included the nest site and prime foraging habitat in Half Moon Bay. Only 2 low use areas were identified, both inland from Jackson Lake and away from the nest site. She appeared to just loaf in these areas.

All 6 use areas defined for EN season were within 4.5 km of the nest proper (Appendix Fig. 41), further illustrating high affinity of breeding bald eagles to an active nest. Although ranging farther during LN season (Appendix Fig. 42), nearly 67% (7 of 9) of use areas defined for the Third Creek female were still within 4 km of the nest. Again, most included prime foraging areas of Second and Third Creeks, Half Moon Bay and the shallow areas present around Donaho Island at medium water level.

It is instructive to note that habitat character of Jackson Lake at low and high water levels was very different. Subjective impressions indicate both fish and waterfowl availability were much higher at low water levels.

Wilcox Point

Bald eagles associated with the Wilcox Point site were first located nesting near Lizard Creek Campground on the north and east shore of Jackson Lake in 1969 (R. Wood pers. comm,). Alt (1980) next found nesting bald eagles on Wilcox Point in 1978. At least 3 sites have been used between 1978 and 1990 with no more than 1 km separating most distant nests.

Three home range polygons were constructed for the Wilcox Point male (Fig. 35). Total home range polygon included 20 RMS (90-110) and was the largest of all GYE eagles monitored. Northern range use was more consistent with wintering activities and therefore segregated from southern range used primarily during breeding season. The northern range included 4 RMS (98-101) and the southern range 10 RMS (80-90). Length of shoreline included was calculated for all polygons for descriptive purposes (Table 22).

The Wilcox Point male was monitored for 1/2 of W season and 1/2 of EN season in 1988, prior to shedding the transmitter. During this period, 23 distinct use areas were defined from 167 individual perches (Appendix Figs. 43 & 36). Of all use areas defined, 56.5% (13) were low use, 39% (9) medium use and just over 4% (1) high use. The high-use area however, was largest and most centrally located in the home range.

The majority of use was located on the Snake River delta as it entered Jackson Lake and mud flats of the exposed lake bed of Jackson Lake. Thousands of waterfowl used the extensive mud flats prior to ice-up and heavy snow cover (Appendix Fig. 44). Subsequently, prey species were concentrated on the river proper, including an apparent high diversity and abundance of fishes.

At the beginning of the EN Season, the Wilcox Point male began frequenting the Snake River in the Parkway near Flagg Ranch and Huckleberry Hot Springs close to those exploited by the Third Creek male and the Polecat Creek Hot Springs just inside the south boundary of YNP (Appendix Fig. 36). Many elk concentrate there each winter and presumably both eagles exploited readily available elk and moose carcasses winter and hunter killed. Polecat Creek Hot Springs area also was inhabited by waterfowl, presumably fed on by bald eagles. The Wilcox Point male remained in the YNP and Parkway area for 5 days then returned to Jackson Lake. Use was concentrated on the Snake River thereafter (Appendix Fig. 45) but he made occasional half day ventures to the Parkway area approximately every 10 days, always returning to the nesting area the same day. He shed his tail mounted transmitter in early April.

Habitat Indices

River Diversity Index

RDIs were calculated for 80 RMS of the Snake River from Palisades Reservoir to Jackson Lake (Figs. 36 & 37). LSR included RMS 0-30, but RDIs were calculated differently than for SP and ST. SP included RMS 31-50 and ST included RMS 51-80. Mean RDI for the LSR was 0.65 (range 0-1.6). Mean RDIs for SP and ST were 9.3 (range 5.7-17.6) and 7.37 (range 0.31-15.6), respectively. RDI indicated a reduction of diversity for RMSs within 5 miles of instream reservoirs, both upstream and downstream. Diversity in free flowing sections increased as the flood plain widened and tended to decrease in canyons. A slight tendency of decreasing diversity was evident as RMS progressed north.

Lake Shoreline Diversity Index

The number of Lake Shoreline Segments (LSS) of Jackson Lake varied with water level which fluctuated throughout the duration of monitoring bald eagles associated with the Third Creek nest site (Fig. 3). Between April and August 1987 during monitoring of the Third Creek adult female, water level was considered "medium" while between 2054 and 2057 m elevation (msl). During radio tracking of the Third Creek adult male, water level was first "medium" from June until September 1988, "low" ($\leq$2053 m) from September 1988 until April 1989, and "high" ($>$2057 m) from April to August 1989.

During high water, 58 LSS were delineated on Jackson Lake; 44 around the mainland shoreline, one included all of Donoho Island and Elk Island had 4 segments. Medium water level resulted in 4 fewer LSS overall, segments around Donoho Island increased to 2 while 4 remained around Elk Island. Total LSS at low water was 35, a 60% reduction from high water level. Donaho Island became incorporated into the mainland which included a total of 29 LSS. LSS around Elk Island increased to 6.

Mean Lake Shoreline Diversity Index (LDI) decreased with declining water level and was significantly different among 3 levels ($P<0.000$, Kruskal-Wallis tests). Pairwise comparisons (Snedecor and Cochran 1988) indicated significant differences in mean LDI among all water level comparisons (Table 23). LDI ranged from 0 to 7.01 at high level, 0 to 5.63 at medium level and from 0.16 to 3.65 at low level. Mean LDI and deviation were lowest at low water level. Narrow deviation and lack of zero LDI values suggests that habitat diversity at low water may have been more consistent and evenly distributed around the Lake than at higher levels, when high diversity areas were fewer, individually more concentrated and collectively farther apart.

Habitat Suitability Index

Habitat suitability appeared to be a function of RDI and CEM. The relationship was therefore expressed as a habitat suitability index (HSI), whereas RDI of RMSx was multiplied by CEM of RMSx. HSI for LSR, SP and ST are shown in Figures 38 and 39.

Home Range Diversity

Mean Home Range Diversity Index (HRDI) for 5 bald eagle pairs in the LSR was 24.04 (range 11.5-30.4). The Sheep Gulch pair included portions of Palisades Reservoir in their home range, thereby increasing overall diversity (not reflected in range diversity calculation). Excluding Sheep Gulch, HRDIs were remarkably similar and high among the 4 remaining bald eagle pairs in the LSR (Fig. 40). This suggests that although significant differences in size, shape and number of river miles included in bald eagle home ranges exist, all are adjusted to include a minimum amount of diversity.

Mean HRDI for SP was 9.34 (8.79-10.53) and 6.6 (4.81-9.31) for ST (excluding lake-nesting pairs). Again as in LSR, one eagle pair included portions of a large reservoir in the home range. Oxbow included portions of Jackson Lake in the home range, thereby adding to the range diversity not reflected in calculation using only river parameters. Excluding Oxbow, mean HRDI for ST was 7.04, more similar to SP. The Schwabacher pair included portions of Taggart, Jenny and Leigh lakes in the home range, which probably increased diversity even more. Including this added diversity, the resultant mean diversity for ST bald eagle ranges may be even more similar to SP ranges than indexes indicate. Similarly, mean HRDI for all bald eagle ranges in SP and ST was 7.97 ± 1.35 ($\alpha=0.05$, $P<0.0001$). Relatively little deviation in Home Range Diversity may indicate as in the LSR, bald eagles in SP and ST adjust home range configuration to include a threshold amount of diversity.

Human Activity in the Snake Unit of Wyoming

Human activity in the Jackson Hole area (SP and southern ST) surrounding the Snake River is mostly seasonal and recreation related. The region is internationally known for good cross-country, helicopter and downhill skiing, spectacular scenery, excellent cold-water fisheries, hunting, trapping, camping, picnicking, hiking, wildlife viewing and boating. GTNP is a particularly strong attractant.

Recreational River Use

Recreational river use in the upper section of the LSR between Astoria and Elbow was sampled by timelapse photography for 41 days between 18 July and 28 August 1987. The camera was located in RMS 15, west shore. The lower section of the LSR between Elbow and Sheep Gulch was sampled for 14 days between 30 July and 12 August 1987 and the camera located in RMS 4, north shore.

Extreme differences in river use were evident between the 2 sections (Table 24). Over just 14 days, 10607 people in 2162 watercraft floated the lower section. Over 41 days, 1841 people in 697 watercraft floated the upper section: In just 1/3 the time, nearly 6 times more people floated the lower section in 3 times the number of watercraft. Not only was the volume of river traffic greater in the lower section, but density of watercraft and people as well. The number of incidents per day was nearly 6 times greater in the lower section (Fig. 41) and interval between incidents nearly 20% smaller than the upper section (Fig. 42). Consequently, the time the river was occupied by recreational traffic was 4 hours longer each day in the lower section and usually began and ended 1 to 2 hours later.

Visitor-use figures for the period 1 January through 31 August 1990 for GTNP are descriptive of human activity levels within the Park. Total visitors for 1990 were 2,053,494 (T. Pentcoast pers. comm.). This figure was an estimate derived from traffic entering Moose and Moran entrance stations and expected traffic traveling U.S. Highway 26/89 through the park. If only 1% of visitors visited areas used by bald eagles, over 20,000 people could potentially impact bald eagles.

More applicable to impacts on bald eagles, total floats along the Snake River was 5,172 watercraft containing 49,691 people. Commercial floats were fewer than private but contained more people. Commercial trips averaged 17 people per float while private floats average 4.5 people per float. Concessionaires are highly regulated and generally sensitive to wildlife values. Private floaters are potentially a much greater problem impacting bald eagles on the Snake River due to their greater number and generally uncontrolled nature and behavior which often conflict with bald eagles.

Amount of Bald Eagle Habitat Removed by Human Activity

Percent perching or foraging habitat available (CEM) in association with human activity per RMS was evaluated with Montopoli and Anderson's (1991) Cumulative Effects Model. Mean CEMfor perching was 58.59 (SD = 26.93) between RMS 0 and RMS 30. Range of

CEM was 11.3 - 94.5 (Fig. 43), with mode of 94. Low CEMs tended to be down stream of RMS 15, associated with high use campgrounds and boat launches for both private and commercial floats. Fewer pulloffs and campgrounds, both developed and undeveloped were upstream of RMS 15, and were reflected in higher CEMs.

Figure 44 shows calculated CEM values for perching per RMS from SP through ST (RMS 31-80). SP had significantly less perching habitat available due to human activity than ST (Mann-Whitney test, P = 0.04). Mean CEM for perching was 47.76 (SD = 34.6) and 69.06 (SD = 29.2) for SP and ST, respectively. Site and time specific perching CEM for the Schwabacher Male averaged 75.25 (SD = 14.3).

CEM values for foraging habitat remaining per RMS are shown in Figure 45 for LSR and Figure 46 for SP and ST. Foraging CEM showed the same trend as perching CEM. Mean CEM for foraging in LSR was 69.26 (SD = 26.29), 58.7 (SD = 37.7) in SP and 76.8 (SD = 26.1) in ST. Less foraging habitat was available to bald eagles in SP than in LSR and ST and P value may indicate biological significance although statistical significance was lacking (P = 0.14).

Bald Eagle Responses to Human Encounters

Tables 25 and 26 present flushing distances of eagles in response to 4 categories of human activity in LSR and ST respectively. Wilcoxon and Mann-Whitney tests showed no differences in flushing distance by category.

Circumstances of 126 encounters between resident eagles and humans were observed sufficiently to permit further analysis. The majority were recorded in ST, fewest in SP with LSR intermediate (Table 27). Distribution was more representative of observation effort and observability of events rather than frequency of eagle-human encounters. Mean flushing distance for all encounters was 180.6 m (SD = 190.3). Mean flushing distances for resident bald eagles noted in LSR, SP, and ST are shown in Table 28.

Pairwise comparisons (Snedecor and Cochran 1988) indicated significant difference between mean flushing distance in the LSR and the River portion of ST (P = 0.0063). Eagles flushed at greater distance in ST. Comparisons also showed significant difference between flushing distance within ST. Mean flushing distance was significantly greater along the River than on the Lake (P = 0.025). Sample size in SP was very small and mean distance especially influenced by one very large distance: 804 m. That eagle was on a gravel bar and was presumed to have responded to an especially boisterous group in a large raft. Eliminating this observation, mean flushing distance in SP was 60 m (± 95.5, α=0.05).

Although mean flushing distance is instructive in evaluating effects of human activity on bald eagles, the relationship between number of eagles that flushed compared to number that did not at the same distance is more so. Figure 47 indicates proportions of eagles that flushed when human activity (of all category types) was encountered within each distance class. Most eagles flushed per encounter at distances under 150 m and a significant drop in percentage was evident at distances beyond 200 m. High proportions at greater distances, i.e. 75% @ 400-450 m and 100% @ 750-800 m probably was a function of small sample sizes, especially at > 750 m, plus difficulty of evaluating if eagles were actually responding to human activity beyond 400 m. Figure 48 indicates cumulative percent eagles flushed by distance class. Cumulative percent of eagles flushed decreased dramatically after 200 m.

Noted Extremes in Bald Eagle Tolerance to Human Presence

It became evident over the course of study that bald eagles may have become habituated to or even ignored human activity very close to occupied perches and nest sites. A theme consistent among these notable exceptions was that human activity or presence close to perches or nest sites occurred under certain strict constraints. Activities that occurred at relatively predictable times at constant intensities or frequencies and within clearly identifiable spatial limits which were seldom violated were sometimes tolerated. Such activities appeared tolerated even when eagles were perched on the ground. Often there were physical or visual barriers between the activity and the eagle which when crossed, made violations obvious. However, if violations did occur, eagles exhibited a much more distressed response than typical flushing behavior. Flushes from perches were more abrupt, and flights more direct with much greater alacrity and distance.

During over 90 observations, the Schwabacher male in ST perched within 50 m of the nest, did not flush from watercraft passing within 10 m of the base of the perch tree, provided the rate of movement was constant and rafts did not stop (GTNP regulations and river bank signs prohibit pedestrian traffic and rafts from stopping within 400 m of bald eagle nests on the Snake River). However, flushing distances were much greater when he was in foraging areas away from the nest or if rafts slowed or stopped near the nest (in violation of regulation). Similar situations were noted for the Butler Creek Female in SP. It also became obvious to researchers that bald eagles throughout the GYE were well aware they were being watched by humans. Many times radio trackers and observers could not approach eagles as close as oblivious citizens conducting daily routines or recreating without noticing nearby eagles.

Tolerance for human presence and activity was noted at other nest sites in the GYE. The Hoback pair in the LSR nested less than 200 m from U.S. Highway 26/89, 130 m from an undeveloped pullout often used for camping and 44 m from the shoreline of the Snake River. A stock trail also ran immediately adjacent to the base of the nest tree. Intensive highway reconstruction occurred on the section passing adjacent to the nest in spring and summer 1988, but eagles displayed no apparent reaction and fledged young. The pullout was used for picnicking and camping annually throughout the years depending on snow cover; use was most intense in May through September. Each spring (approx. 6 June) livestock and associated drovers trailed under the active nest. Also each spring (early April) vociferous and excessive river traffic associated with the "Pole, Paddle and Peddle" competition passed on the Snake River directly under the nest. Each year, including 1990, the pair produced young.

There was no timber between the Hoback nest and above activities for visual buffering. Significant topographical barriers, however, effectively insulated the nest site from most human intrusion. The nest tree was situated on a very steep slope, eliminating any direct access from the river bank. Similarly, access from the highway or pullout was eliminated by steepness of slope on each river bank and the formidable barrier of the Snake River itself. The only activity which violated the nest site proper was livestock trailing but eagles apparently tolerated this brief, albeit significant intrusion. Livestock and drovers kept moving and generally ignored the nest and parent eagles and the nest proper was not violated.

Although high and medium use areas of the Hoback pair included recreational, housing and commercial developments, few people seemed to notice eagles. Timing of use varied throughout the day and Hoback eagles did not appear to modify their movements in response to normal human activity levels.

Nests of the Elbow pair of eagles were situated in the most intensively used section of LSR and eagles were subjected to almost constant human presence within 300 m during summer. Initial nest (which ultimately failed) in 1987 was located 155 m from the Elbow campground and 311 m from the boat launch, in direct line of sight of the opposite shore. In 1988-1990, the nest was located 300 m from the campground and 489 m from the boat launch; in each of these years the Elbow pair fledged young. Adult eagles were observed perching in trees directly over the occupied campground in early morning and evening, when human activity was minimal. The Elbow male had fledged from a nest in the Ford's breeding area in SP and may have become habituated to humans though constant exposure on the Snake River.

First nesting of bald eagles at the Third Creek site occurred in 1987 while reconstruction of Jackson Lake Dam was under way; site selection and occupancy may have occurred during construction. Construction activities were not visible from the base of the nest tree nor the nest proper. However, sound emitted from support vehicles, heavy equipment (especially reverse alarms), dynamic compaction, and human voices were quite evident and sounded "next door". In 1987 and 1988, the Third Creek pair fledged young. In 1990, when reconstruction activity was no longer present, the nesting attempt failed. Each year during banding at the Third Creek site, the adult female remained perched 1/2 way up a lodgepole pine (*Pinus contorta*) 150m east of the nest tree, remaining quiet and apparently unconcerned as the banding team approached. However, as the climber approached entering the nest she became very animated, vocalizing loudly and circling the nest quite close.

The Jardine nest site in the CM was first occupied in 1988 and located 172 m from construction and operation of a tailings impoundment pond of the Mineral Hill Mine. The nest was also 406 m from the Jardine Road and reconstruction and related activities in 1989. Road reconstruction and tailings impoundment construction involved use of heavy equipment, blasting, human activity, traffic and survey and construction of a power line (within 200 m of the nest site). During the Yellowstone "Fires of 1988", a helitac base was situated within the range of the Jardine pair and flight paths passed directly above the nest at about 250 m, before diverted for bald eagle concerns. Although nest site occupancy and selection occurred prior to intense activity, the Jardine pair fledged young during all 3 years of occupancy. Strict management of levels, times and locale of construction and human activity was attempted; however, the influence of this management on ultimate success of the pair is unknown.

Tolerant bald eagles were subjectively more aggressive during banding operations than those considered less tolerant. At least one member of tolerant pairs continually vocalized and perched close to the nest (or even *in* the nest!) during climbing. Some adult eagles defended the nest by vigorous stoops at the bander in or near the nest, posing a significant threat. In one instance (Culver Springs in the CM of southwestern Montana), the bander was actually struck by the stooping eagle. In nearly all instances where nest defense was obvious, the most aggressive eagle was the female. Males were usually out of sight or circling high above.

Foraging Ecology

Circumstances of 119 foraging attempts by resident adult bald eagles were recorded in the LSR. Time (precise or ± 10 min) was recorded for all attempts but vegetative and topographical screening, logistics and desire to induce least possible observer disturbance to the foraging eagle prevented detection of precise location and outcome of some attempts. Accordingly, 87 foraging attempts were located precisely, 119 to RMS and 112 attributed to a specific eagle or pair. Data from all seasons were pooled for analysis.

Bald eagle foraging data in SP were too few and too sparsely documented to permit analysis. Only 5 foraging attempts were noted, all with unknown outcome. All were in RMS 34 and 35 and none >800 m from the nest. The Butler Creek female bald eagle was monitored primarily by triangulation of signals and was visible only when flying, on perches or in the nest. In ST, 167 foraging attempts were observed, 46.7% of attempts were by radio-tagged resident adult bald eagles.

Prey

Of 74 successful foraging attempts of bald eagles observed in the LSR, 60 prey items taken could be identified to class. Over 96% (58) were identified as fish but only 11 identified to genus, including 2 identified to species: a cutthroat trout and a mountain whitefish. The remainder included 7 suckers (Catastomidae) and 2 trout (Salmonidae). Mean estimated length of piscean prey was 36.8 cm (SD = 15.7cm).

One avian prey item was taken - a lesser scaup (*Aythya affinus*) and a large ungulate carcass fed upon, both by the Sheep Gulch male. Avian (especially waterfowl) and mammalian prey were certainly under represented. Eagles probably were hunting or eating birds or mammals during long periods when eagles were out of sight both on and off the river and during unsuccessful or unknown foraging attempts. Several times target eagles were drawn to large ungulate baits, suggesting a search image for carcasses. Eagles (especially the Dog Creek pair) spent periods off river in areas and during time when hunter-killed ungulate carcasses, viscera piles or ground squirrels were present.

Five instances of piracy were noted. Cabin Creek male appropriated a fish from a river otter on the ice and another fish from a great blue heron, as did the Sheep Gulch male. The Sheep Gulch male and the Elbow male both pirated a fish from osprey (*Pandion haliaeetus*).

Of 51 successful foraging attempts of bald eagles observed in ST, 47 prey items were identified to class. Fish comprised 68% of known prey items, mammals 28% and birds nearly 9%. No fish were identified to genus. Mean estimated length of fish taken was 35.5 cm (SD = 5.08, N = 3). Few estimates of prey lengths were available due to extreme observation distances. Four birds taken live were identified, a hatching year common merganser, a drake redhead (*Aythya americana*), an American coot (*Fulica americana*) and a drake Barrows goldeneye (*Bucephala islandica*). Three ground squirrels were taken in sage (*Artemisia* spp.) flats bordering the Snake River, all by Oxbow pair. Of the remaining 10 mammalian prey, 9 were winter-killed elk and 1 moose.

Piracy or attempted piracy was observed between bald eagles in ST and ravens, common mergansers, osprey, great blue herons and river otters. In some cases, river otters appeared as if they were feeding eagles. Otters brought fish up on the ice, laid them out and backed away. Eagles took the fish while otters watched.

In 1988, 2 immature eagles radio-tagged in the GYE were observed in an apparent commensal relationship with a radio-tagged sow grizzly bear (*Ursus arctos*) in the vicinity of Lake Lodge near Yellowstone Lake. Located along small creek known for spawning cutthroat trout, the bear was seen snagging spawning trout, lacerating the gut and selecting for row. The carcass was then discarded. Radio-tagged eagles were observed scavenging carcasses when the bear moved off about 3 m. The bear and eagles remained in the vicinity for 1 week but discretion dictated minimizing observation time. The grizzly was subsequently located in Pelican valley, again along streams in which cutthroat spawned. Within 1 day, eagles also were located there.

Foraging Time

Figure 49 illustrates temporal distribution of 119 foraging attempts noted for all LSR adult bald eagles by hour block. A bimodal foraging pattern (attempts per hour period) is evident, peaking between 0800 and 0900 hrs MST and again between 1800 and 1900 hrs. During just 2 circadian hour periods (12.5% of daylight available), 24.4% of all foraging attempts occurred. Most foraging activity, however, occurred before 1000 hrs., when 50.4%

of all attempts were noted. Observability bias was considered insignificant but was certainly greater for nonradio-tagged vs. radio-tagged eagles. Although sample size and monitoring intensity were different, timing of trends in foraging activity was similar between radio-tagged eagles (Fig. 50) and nonradio-tagged eagles (Appendix Fig. 46).

Distribution of foraging attempts by all bald eagles observed in ST by hour period is shown in Figure 51. A bimodal pattern of foraging activity (attempts per hour period) is evident for radio-tagged bald eagles in ST (Fig. 52). Foraging pattern by hour period by nonradio-tagged bald eagles, including resident and migrant adults and immatures, showed a similarity to radio-tagged eagles, but was more evenly distributed across the day (Appendix Fig. 47). More even distribution was probably a function of more serendipitous nature of observations and propensity for immature bald eagles to forage more evenly throughout the day.

Distribution of foraging activity among adult eagles was similar throughout the study area (c.f. Figs. 50 & 52). However, adult eagles in ST tended to forage more often, 2 hours later in morning (0700-0900 vs. 0700-1100) and 1 to 2 hours earlier in evening (1700-1900 vs. 1600-1700) than adult eagles in the LSR.

Seasonal distributions of foraging success corrected for time monitored indicate a bimodal pattern of foraging activity of radio-tagged bald eagles in ST. Although somewhat less obvious than for uncorrected pooled results, modes of activity were evident in late morning and evening during June through August (Fig. 53). However, a more even distribution is evident in the September through May period (Fig. 54) and may have been a function of less predictable or available food during winter and spring and/or the absence of human activity permitting less restricted movement.

A distinct bimodal pattern of foraging activity is evident for nonradio-tagged eagles observed in ST in June through August (Appendix Fig. 48). Two modes of foraging activity were between 0800 and 0900, and 1800 and 1900 hrs. During September through May a more bell-shaped distribution of foraging activity was observed (Appendix Fig. 49) and was more consistent with activity of wintering eagles elsewhere (Harmata 1984).

Foraging Success

Foraging success per hour period for radio-tagged and nonradio-tagged adult bald eagles in LSR is shown in Figure 49. Sample sizes were different between eagle groups (tagged vs. not) but trends in foraging success were similar. Of 109 foraging attempts of known outcome witnessed, overall success was 68.8%. Radio-tagged eagles' foraging success was 70% and foraging success for nonradio-tagged eagles 66.7%. Success rate appeared to vary inversely with number attempts, which was related to time of day (n.b. Figs.50 & Appendix Fig. 46). Increased numbers of attempts for all eagles in mid morning and early evening tended to be associated with less success. Conversely, fewer attempts during midday to afternoon resulted in greater success. Overall, number of foraging attempts were significantly more frequent before noon than after noon ($X^2=23.4$, 8 df, $P<0.003$). However, frequency of successful attempts was significantly greater afternoon ($X^2=18.7$, 7 df, $P<0.01$). Success of a radio-tagged eagle that included only Snake River in its range (Cabin Creek male) was very high (88.8%). The radio-tagged Sheep Gulch male that nested on the Snake River but foraged primarily at the confluence of Snake and Grey's Rivers and portions of Palisades Reservoir had lower success (60.4%). Foraging success was not correlated to mean perch to forage distances ($r = 0.30$, $P = 0.01$).

Overall foraging success (% successful of all attempts with known outcome) of all bald eagles observed in ST was 56.8%. Foraging success for radio-tagged adult bald eagles in ST was 58% and very similar to overall success of nonradio-tagged eagles (55%). During summer (June through August) radio-tagged eagles had considerably less success overall when foraging during late morning modes, 0900-1200 hrs. (Fig. 53). Nonradio-tagged eagles were also less successful in morning (0800-1100 hrs.) (Appendix Fig. 48). For winter (September through May), success for both groups of eagles was more even throughout the day.

Specific to individual radio-tagged eagles, foraging success ranged from 25% to nearly 82% (Table 29). Adult female bald eagles tended to have a higher success rate (68%) than males (51%) but overall success of males was heavily weighted by the lack of success of the Wilcox Point male (25%). The Oxbow male's success was also low, and both he and Wilcox Point male were monitored roughly during the same period (Table 10). Possibly all eagles monitored during just this period have low success, not evident when multiseasonal data are lumped as here. Excluding the Wilcox Point male, male success was not significantly different from female, although still lower. In fact, Third Creek male had the highest foraging success recorded (81.8%).

Again excluding the Wilcox Point male that was monitored only portions of 2 seasons, eagles associated primarily with lentic systems (Third Creek pair) tended to have higher overall foraging success than those associated with lotic systems (Schwabacher male, Oxbow pair). However, success during winter for the Third Creek pair was poorly documented as both members apparently left the breeding range and Lake during winter, whereas eagles resident primarily on the River did not.

Foraging Location

Distance between foraging attempt locations and respective most recently occupied nests (forage to nest distance) for all eagles monitored varied from 47 m to over 10 km ($\bar{x}=2$ km, SD=2.4 km). ANOVA (unweighted means) determinined significant differences of forage to nest distances among all eagles ($P<0.00$). Duncan's Range Test ($\alpha=0.05$) revealed groups of eagles with similar forage to nest distances. Generally, eagles foraging exclusively on the Snake River had smallest forage to nest distances, eagles with lakes included in their home range had intermediate forage to nest distances while eagles foraging primarily on lakes had largest forage to nest distances.

Cumulative percent of foraging attempts by distance class from nest were plotted and curves fit by logit regression analysis (Appendix Figs. 50-53 & 55). High R^2 values resulted and indicate regression curves are useful for comparing forage to nest distances among different eagles. Values calculated at the 50% level (i.e. distance from the nest at and below which 50% of foraging attempts occurred) were chosen for comparison among eagles. The 50% level is the inflection point on the sigmoid logit curve. Also, increasingly greater distances included smaller cumulative percentages of perches after the 50% distance.

Forage to nest distances for 11 eagles or eagle pairs ranged from 256 m to 3.9 km at the 50% level (Table 30). Forage to nest distances at the 50% level for 6 of the 11 eagles occurred within 2 km, suggesting most eagles forage within 2 km of the nest. Five eagles or pairs had forage to nest distances greater than 2 km at the 50% level (Table 30). The Sheep Gulch Male and Hoback pair had home ranges that contained significant portions of the Snake River with low HSI ratings (Fig. 38). The Schwabacher male periodically foraged on lakes between 5.6 and 10.4 km away. Both eagles of the Third Creek pair foraged primarily on Jackson Lake. Forage to nest distances at the 90% level varied greatly (0.6 to 8.5 km) among eagles and pairs.

Distances between preforaging (previously occupied) perch and foraging locations were calculated for eagles monitored and combined into 2 groups. River eagles consisted of all those associated with nest sites along the Snake River in SW; lake eagles were Third Creek male and female and Wilcox Point male. Individual cumulative percent, preforaging perch to forage location curves determined by logit regression analysis are shown in Appendix Figures 54 and 56 through 58. High R^2 values were associated with all analyses indicating curve profiles are useful in describing and comparing perch to foraging patterns (Table 31).

Distances between preforaging perches and foraging attempts were roughly twice as far for radio-tagged eagles commonly exploiting lake habitat as compared to those foraging primarily in river habitats. Difference between the 2 groups was significant at the $P = 0.000$ level (Mann-Whitney test). Actual distances for lake eagles ranged from 106 m to 3.1 km ($\bar{x} = 995$ m, SD = 847) with 50% within 698 m and 90% within 2.2 km. Logit regression analysis predicted 50% of all foraging attempt distances from a preforaging perch by lake eagles to be 594 m at the 50% level and 1.9 km at the 90% level (Table 31).

Actual distances of foraging sites from preforaging perches for radio-tagged eagles foraging along the Snake River varied from 12 m to 4.2 km ($\bar{x} = 365$ m, SD = 526 m). Fifty percent were within 179 m and 90% within 786 m. Distances of preforaging perch to foraging attempt predicted by logit regression analysis at the 50% level for river eagles was 207 m and 808 m for 90% level. Increased foraging distance for lake eagles was probably related to increased visual exposure. Prey was probably more dispersed in lentic areas also. The Snake River in the ranges of the Butler Creek pair, Schwabacher male and Oxbow pair was often sinuous, contained islands and was lined with timber. Line of sight was often less than 200 m from many perches used for foraging.

The Third Creek Female had largest overall foraging distances ($\bar{x} = 1.7$ km, SD = 1.1 km) with 50% within 2 km and 90% within 3.1 km. Although sample size was small, these distances appeared typical of her foraging behavior. She commonly would hunt during extended soaring flights and strike at prey from great heights after circuitous flight paths. Consequently, several foraging attempts could not be assigned a realistic distance (except line-of-sight) from the previous perch nor could the point at which she perceived a foraging opportunity be determined.

Preforage perch to forage distances of all males were similar (Appendix Figs. 56 - 58) and representative of more aggressive, direct pursuit foraging behavior of the gender. Oxbow male and female were similar although sample sizes where very different (male N = 3; female, N = 24). If more locations of Oxbow male had been available, they may have indicated a stronger similarity to overall male foraging distances.

Foraging Relationships in the Lower Snake River

Distribution of 108 foraging attempts of bald eagles in the LSR located by RMS is shown in Figure 55. Of 106 foraging attempts attributed to a specific eagle or pair and located by RMS, 32% occurred within the same RMS as the nest. More foraging attempts occurred within the same RMS as the nest than any other RMS in the home range for nonradio-tagged pairs of eagles in the LSR (70%), but distribution was probably a function of lack of observability of RMSs away from nest sites of unmarked eagles. More foraging attempts occurred in RMSs other than those that contained the most recently active nest for radio-tagged eagles. Cabin Creek locations showed most attempts in the RMS immediately adjacent to that which contained the nest, but most attempts by Sheep Gulch eagles occurred at least 2 RMS removed from the nest (Fig. 56), in the deltas of the Snake and Grey's Rivers and portions of Palisades Reservoir.

Distance of foraging attempts from the nest site varied considerably in the LSR. Distances differed significantly between Sheep Gulch and Cabin Creek radio-tagged males (Mann-Whitney test, $P<0.05$). Cumulative distribution of foraging distances showed 90% within 3.2 km of the nest for Cabin Creek male but over 6.8 km for the Sheep Gulch male (Appendix Fig. 50). Similarly, 90% of foraging attempts for the Dog Creek pair of nonradio-tagged bald eagles were within 524 m but for the Hoback pair, fewer than 25% were within 400 m (Table 30). Ninety percent were within 4.5 km. All foraging attempts for the Elbow adult bald eagles were within 300 m of the nest (Table 30).

No correlations were found for pooled data of total foraging attempts of all eagles observed by RMS with either HSI, foraging CEM or RDI, but a weak correlation was found for number of foraging attempts per RMS and perching CEM ($r = 0.35$, $P<0.05$). However, discriminate analysis chose up to 10 HCVs whose proximity discriminated between used and nonused foraging locations, depending on scenario (Table 32). In each case, proximity to the nest site was the most discriminating variable. Excluding consideration of the nest, HCVs important in foraging location for eagles not including a portion of a lake in their home range were proximity to islands, deep runs and stream confluences. Deep pools and confluences of intermittent streams appeared to be avoided. Eagles that included portions of lakes in their home range seemed to select condition opposite of those selected by their contemporaries residing on free flowing sections of the Snake River (Table 32). Distances between used and nonused FORAGE location and respective HCVs were often large (Table 33) indicating important HCVs were truly selected for.

Nest Site Selection

Mean RDI for RMSs which contained most recently active bald eagle nests along the Snake River was consistently higher throughout the study area (Table 34). Most (75%) bald eagle pairs located their nests in or adjacent to RMSs with the highest RDI in their range (Figs. 36 & 37). Percentage increased to 92% if pairs which included large lakes (which effectively increased overall range diversity) within their range are excluded; Sheep Gulch, Schwabacher and Oxbow pairs all commonly included lentic systems in their range. RMSs with the highest RDI in a respective bald eagle's range but without a nest site were immediately adjacent and directly accessible from the nest; i.e. RMSs with highest RDI in the home range were so close to the nest as to permit access visually or by short flight.

Mean CEM for perching in RMSs with bald eagle nests in the LSR was 56.58 ($N = 6$, $SD = 21.4$), slightly lower than for RMSs without bald eagle nests ($\overline{x} = 60.4$, $SD = 26.8$, $N = 25$) but not significantly so (Mann-Whitney, $P = 0.697$).

Nest sites were located near confluences of major peripheral streams (Sheep Gulch, Bailey Creek, Martin Creek and Dog Creek) as were campgrounds and pullouts. Eagles appear to select for components of habitat that are also conducive to placement of campgrounds in LSR.

Mean percent perching habitat available (CEM) in RMSs containing bald eagle nests in SP ($N = 5$) was higher than RMSs without eagle nests ($N = 19$) (Mann-Whitney test, $P = 0.1513$). Mean perching CEM for RMSs with and without bald eagle nests were 67.9 ($SD = 35.88$) and 37.26 ($SD = 30.22$), respectively.

In ST, mean perching CEM was 81.56 ($SD = 18.22$) for RMSs with eagle nests ($N = 5$) and 67.62 for RMSs without eagle nests ($N = 31$). P value indicated no significance difference (0.5547).

Similar trends were found in relation to foraging habitat remaining in RMSs with and without bald eagle nests. Eagles tended to nest in RMSs with less foraging habitat withdrawn by human activity. Mean foraging CEM in RMSs with bald eagle nests in SP was 27% higher ($\bar{x}$ = 71.28, SD = 39.59) than those without nests (51.65, SD = 37.14) but difference was not significant (Mann-Whitney test, P = 0.4313). In ST, RMSs with eagle nests had mean foraging CEM of 89.76 (SD = 4.09), 16% higher than those without nests ($\bar{x}$ = 75.04, SD = 27.61). Again, difference was not significant (Mann-Whitney test, P = 0.485).

Comparison of HSI values for RMSs that contained most recently active bald eagle nests and RMSs which did not, showed eagles tended to choose RMSs with higher HSIs, although differences were not always significant (Table 35). Considering mean CEM and RDI values that composed HSI of RMSs with and without nests, bald eagles nesting along the Snake River appeared to consistently select areas of high quality habitat but with varied availability, especially in the LSR. LSR is subject to intense recreational pressure and eagles may have adapted strategies of avoiding human activity temporally, seasonally *and* daily which effectively increase perching CEM not reflected in calculations. In fact, when CEM values were applied to RMSs temporally, perch use differences among RMSs were significant and inversely correlated.

Proximity of Nest Sites to Habitat Components in Lower Snake River

Table 36 illustrates mean minimum distances of all habitat components analyzed to used bald eagle nest sites (weighted) and nonused sites in LSR. Table 37 shows 10 habitat component variables (of 24 analyzed) selected as important in discriminating between used and nonused bald eagle nest sites in LSR. Most important variable was proximity to the Snake River, followed by houses, riffles in the Snake River and meadows. In each case, used bald eagle nest sites were closer than nonused sites to respective habitat components. Of 4 variables with highest partial R^2, only one had a negative implied selection relationship (ISR). Proximity of houses (HOW:Table 37) was closer to nonused sites than used nest sites by 215 m, suggesting bald eagle avoidance of structures associated with continuous human activity. Few houses were located away from Hoback Junction, Astoria and Alpine but 4 of 5 eagle ranges in LSR were.

Spatio-temporal Perch to Nest Relationships

Perch to Nest Distance

Cumulative percent of perches by distance class from the nest were graphed and curve fitted by logit regression analysis (Appendix Figs. 51 & 59-63). High R^2 values resulted from all logit regression analyses of perch to nest distances (Table 38) and indicate calculated (predicted) curves are useful in comparing movement patterns among different eagles. As with other distance/location analyses, distance values calculated at the 50% level by logit regression were chosen for comparative purposes. Results suggest amount of use a portion of the home range received by resident eagles was partially related to distance from the most recently active nest.

Curves of cumulative percent of all recorded perches to nest by distance varied greatly among individual eagles or pairs monitored (Appendix Figs. 51 & 59-63). Perch to nest distances at the 50% level, calculated by logit regression formulas, varied from 540 m to 4,434 m. As indicated by logit regression calculations, 9 of 12 data sets from eagles or eagle pairs monitored showed perches within 2 km of the nest over 50% of the time (Table 38). Two eagles (Sheep Gulch male and Third Creek male) had perch to nest distances greater than 4.3 km at the 50% level; while Schwabacher male (1987, 1988) was intermediate with 50% of the perches occurring within 2.5 km. Ninety percent of all perches of all eagles monitored were under 10 km from the most recently active nest (range 1.31 km to 9.95 km, Table 38). Distances calculated (predicted) by logit regression analysis ranged from 1.29 km to 9.15 km at the 90% level (Table 38).

Temporal Perch Use

All perches of the Schwabacher male bald eagle (monitored for an entire annual cycle) were categorized by hour period and distance class (in 100 m increments). Probability values were assigned to each hour period/distance class cell based on number of perches and duration of use contained therein. The Schwabacher male most likely was between 200 and 300 m of the nest between 0800 and 1000 hrs MST (Fig. 57). Another mode of high probability was evident between 1500 and 1800 hrs, again between 200 and 300 m from the nest but probability was less.

Radio-tagged eagles nesting on Jackson Lake showed a different distribution of temporal perch use (Fig. 58). Eagles perched over 3600 m from the nest between 1500 and 1600 hrs with the greatest probability, but at the same time also were found within 300 m of the nest with nearly equal but lower probability. Pooled data show any eagle regardless of nesting situation was most likely perched between 100 and 200 m of the nest between 0900 and 1000 hrs in ST (Fig. 59).

Surveys for nest site occupancy by bald eagles, at least in ST may be most accurate when conducted between 0900 and 1000 hrs. At this time resident eagles will most likely be within 300 m of the nest. Surveys between 1500 and 1600 hrs will most likely find resident eagles within 300 m of the nest but with less probability than morning.

Habitat Characteristics of Bald Eagle Use Areas

River Nesting Eagles

Eagles nesting along the Snake River and exploiting habitats there tended to use areas of higher habitat quantity and quality as indicated by CEM and RDI. Comparison of use areas of high or medium use containing 3 or more perches with use areas of low or no use showed significant differences in HSI of RMSs contained in each group. For bald eagles in the LSR, mean HSI for RMSs of high or medium use was 5.99 compared to mean HSI of low or no use RMSs of 2.58 (Mann-Whitney test, $P = 0.0244$). Use area comparisons for SP and ST were pooled because HSI calculation was the same and data from only one eagle in SP were available. Mean HSI of RMSs contained in high or medium use areas of 3 or more perches was 4.48; for low or no use RMSs mean HSI was 1.95. Difference was considered biologically significant (Mann-Whitney test, $P = 0.06$). The number and amount of HCVs contained in home ranges of eagles nesting in the LSR were remarkably similar (Table 39).

Discriminate analysis of used and nonused bald eagle PERCH locations showed 8 variables important in discriminating between used and nonused perches (Table 40). Table 41 shows mean minimum distances of used and nonused perch location from all respective habitat components in LSR. Of 8 discriminating variables, distances of used and nonused perch locations 6 were significantly different. As with nest sites, distance of perches to houses was large and farther than nonused locations. All other used perches were closer to habitat components than nonused locations (Table 41).

Lake Nesting Eagles

Because precise habitat information was lacking for a large portion of the Wilcox Point male's home range, LDI and RDI values were not calculated, hence diversity-use relationships were not quantified. Little relationship among weight of use areas and LDI was found for the Third Creek male and female. Mann-Whitney tests showed no significant difference between mean LDI of used LSS and mean LDI of nonused, randomly selected LSS. Similarly, analysis of use area weight with respective mean use area LDI showed no significant statistical correlations, regardless of category associations, i.e. by sex, season or pooled. Most significant correlation ($P = 0.1132$) however, occurred between mean use area LDI and use area weight for the Third Creek male during winter (Table 42). Correlation was -0.651, indicating lower use of high diversity areas during winter. During most of winter season, Jackson Lake was ice covered so calculated diversity index probably bore little resemblance to actual at that time.

Mean LDI of areas used by the Third Creek male was highest during LN and PF seasons (Table 42). Twenty-four areas were used during these seasons, all intersecting lake shoreline. Low use area weight was probably a reflection of high number of areas used. Third Creek female used 9 areas during EN and LN seasons, 7 that intersected Jackson Lake shoreline. High mean LDI of use areas in EN was probably a function of the compulsion to remain near nestlings and by association, high diversity habitats around the nest site. As tenacity to the nest site waned, she moved farther out on the lake, using associated shorelines of less diversity.

Factors Affecting Productivity and Survival

Weather Severity

Mean WSI per year associated with 4 weather recording stations in the SW are shown in Table 43. ANOVA detected significant differences among station WSI ($F = 86.7$, $P = 0.000$) and among years within stations ($F = 12.4$, $P = 0.001$). Main effects tests indicated station groupings which were exposed to similar weather patterns and also years that differed in annual WSI per station ($P \geq 0.05$). As a result, Moose and Moran data were combined. Weather in 1985 was more severe than all other years at each station except South Gate. However, 1987 was a significantly ($P < 0.05$) milder year than all others at South Gate.

Productivity of bald eagles was inversely correlated with time- and site-specific severity of late winter and early vernal weather as manifested in mean annual WSI (Tables 44 & 45), but overall relationship was weak ($N = 66$, $r = -0.45$, $P < 0.001$). Mean annual productivity for the SW was more strongly correlated (inversely) with overall mean annual WSI ($N = 5$, $r = -0.57$, $R^2 = -0.32$, $P = 0.32$: Fig. 60). Kruskal-Wallis tests showed significant ($P = 0.009$) differences in productivity of eagles associated with 3 areas delineated by different mean annual WSI. Comparing reproductive performance for bald eagles associated with these areas (Table 45), nonparametric Mann-Whitney tests indicated differences in productivity that were accepted as significant. South Park (SP) area productivity was higher than the Moose-Moran (MO/MR) area (P = 0.084) and MO/MR higher than South Gate (SG) (P = 0.072). Mean annual productivity declined as mean annual WSI increased, (Fig. 60) which was manifest in annual fluctuations and progressively upstream along the Snake River.

Multiple regression analysis indicated trends in effects of monthly WSI on productivity, but sample years were too few (5) and months considered too numerous (4) to be statistically valid. Simple linear regression showed the strongest relationship of annual productivity in the SW was to mean WSI of just one month, April (Fig. 60). Annual productivity throughout the SW was inversely related to April WSI and represented the best predictive model of the effects of weather ($R^2 = 0.96$), P = 0.021).

Plotting frequency of number of young produced per individual nesting attempt (whole number result) with mean annual WSI over 5 years indicated a potential threshold of WSI beyond which few young are produced (Fig. 61). Combined results indicate during years when annual WSI was in excess of 150, no young were produced. Also, regardless of mean WSI, few young were produced if April WSI was in excess of 52. None were produced when April WSI was over 81 (Fig. 62).

Habitat Suitability

Correlation analysis of CEM and RDI with bald eagle productivity (young produced per occupancy) showed general trends of mitigating effects of human activity on habitat quality, reflected in reduced productivity. Eagle pairs subjected to greater levels of human activity tended to have less reproductive success, but not in SP (Table 46).

Regression of total young produced per pair from 1978 through 1990 with mean HSI for all RMS in the home range showed relationships between habitat suitability in the home range and productivity per pair (Table 47). Higher production, manifested in longer reproductive history and more young produced, was highly correlated with home ranges of high mean HSI.

Bald eagle nesting density and productivity data from 1978 to 1990 indicated that some portions of the Snake River were more productive than others. Because bald eagle home ranges varied in size, comparisons of habitat quality and eagle production were analyzed relative to a standard habitat unit. Production was defined as number of young fledged per RMS (1978-89). Mean HSI values for Cabin Creek, Dog Creek, Butler Creek and Gills home ranges were compared with HSI values of home ranges that were considered unproductive (Table 48). Weather patterns were different and significantly affected production between SP and ST; therefore, HSI was analyzed independently by area. However, highly productive areas did not occur in ST. Highly productive home ranges had 2 to 3 times higher mean HSI values than ranges with low productivity.

Perch Proximity to Nest Sites

Productivity (young fledged per occupied breeding area, 1978-1990) was regressed with slope of logit regression curve and perch distance from the most recently active nest at the 50% cumulative level. The 50% level is most representative of distance at which eagles most frequently perched and indirectly indicative of proximity of preferred habitat. Little relation ship was found when all eagles monitored were included in analysis (r=0.39, P=0.517). However when grouping genders, analysis showed stronger relationships of productivity with distance of perches from nests, especially for females (Table 49). Productivity correlated positively with slope and negatively with distance in all analyses, indicating more productive eagles perched closer to nests more often and did not range as far as less productive pairs. The tendency held for males and may indicate biological significance, although statistical significance was lacking.

Impacts of Urban Development and Recreation

Excessive human activity associated with housing and recreational development contributed to abandonment of 2 nest sites in YNP and at least one in SP along the Snake River. A bald eagle nest site near Fishing Bridge on the Yellowstone River at the outlet of Yellowstone Lake was abandoned in the mid 1970's coincident campground and satellite recreational facilities development and coincident significant increase in visitor use. No alternate site for the pair has been found and contribution of young to the population from that pair probably has been lost. Also, bald eagles nested on the southeast shore of West Thumb of Yellowstone Lake until the late 1970's when development of extensive visitor dormitories began. No nesting activity has been noted at the site since.

A nest site on private land in SP was consumed by lot 38 of the Solitude subdivision near the southern border of GTNP in 1981. In 1980, the nesting pair fledged 3 young. Three years hence, the Moose pair was discovered and attempted nesting. Reproductive history of the Moose pair suggests it may not be the displaced Solitude pair. Again, potential contribution of young to the GYE population by the Solitude pair was presumably lost.

Recreational impacts were direct and indirect. The RKO site in GTNP was located in an area of high habitat diversity and low human activity (Figs. 37, 44 & 46), but occupancy of the breeding area was erratic and productivity nil. CEM analysis considered only human activity during summer but the RKO site was the only one on the Snake River in GTNP located in an area where snowmobile traffic was permitted in February. Snowmobile's traveled along the top of the bluff above and within 95 m and 260 m of the nest. Raptors are generally considered to be most sensitive to disturbance during nest site selection and copulation (Stahlmaster 1986, Newton 1979), manifested in abandonment of the nesting attempt. These periods occur during January through March for bald eagles in the GYE with peaks in early February, coincident with highest snowmobile use in GTNP. Snowmobile traffic is seldom unobtrusive, quiet or slow and was probably extremely disruptive to RKO eagles.

Indirect impacts of fishing on bald eagle production have been noted in the GYE. During banding of nestlings at the Schwabacher site in 1980, the carcass of a nestling about 6 weeks old was found in the nest entangled in monofilament fishing line. In 1984, a nestling at Ford's site also was found entangled in monofilament line but still alive. Had the bander not freed the nestling, death would certainly have ensued.

Throughout the study period, fish found in bald eagle nests during banding contained hooks but impacts of this type of food contamination on nestling survival is speculative. More insidious may be the impacts of lead sinkers and lead shot lost by anglers and deposited by waterfowl hunters (See *Heavy Metals*, below). Production by the Wilcox point pair has been low (Appendix Table 2). More than any other pair in the SW, Wilcox Point eagles exploited waterfowl, especially in autumn and winter; a time when lead contaminated waterfowl (wounded with and containing lead shot) would be most abundant.

Organochlorine Pesticides and PCBs

Two bald eagle eggs were recovered from 2 nests in 1983; Oxbow and Wilcox Point. Both nests were productive in spite of addled eggs and one eaglet fledged from each. Eggs were sent to Patuxent National Wildlife Research Center, Laurel MD for analysis of pesticide residues and shell thinning (Table 49). Egg shell from the Oxbow nest was found to be 24% thinner than pre- DDT[1] era eggs from the Pacific northwest, and egg shell from Wilcox Point nest was 3% thinner. Predicted average production when DDE[2] concentrations are 4.5 and 2.4 ppm are 0.62 and 0.81 young fledged per nest per annum, respectively. Production over 12 years was actually considerably lower for both nests, being 0.58 for Oxbow and 0.31 for Wilcox Point. Effects of DDT in the food chain may have contributed to low production between 1978 and 1990. In 1989, shell fragments from eagle eggs were recovered beneath the Schwabacher nest. Measurements conducted at Western Foundation for Vertebrate Zoology, Los Angeles, CA showed the thickness of fragments to average 0.609 mm. This thickness was considered to be normal when compared with pre-DDT era eggs from the eastern U.S. and supernormal when compared with pre-DDT era eggs from the Pacific northwest (L. Kiff pers. comm.).

Two nestling bald eagles were recovered dead from the Horse Butte nest on the northeast shore of Hebgen Lake MT (CM population unit) on 26 June 1981 (T. Puchlertz, USFS, Hebgen Ranger Dist. pers. comm.). Carcasses were analyzed for contaminants at Patuxent Wildlife Research Center. Organochlorine residues in both eagles were low (Table 50). However, analysis methods differed and results were not comparable. Regardless, analytical personnel felt contaminants did not contribute to mortality.

Blood of only 1 of 9 nestling bald eagles produced in the GYE (8 in ST, 1 in CM) and analyzed for 16 organochlorine and polychlorinated biphenyl (PCB) compounds showed detectable levels. DDE was the only compound detected in blood of a nestling produced in the Coral Creek breeding area in the Centennial Valley of southwestern Montana (CM) and concentration was 4 parts per billion (ppb).

Organophosphate and Carbamate Insecticides

ChE analysis of blood of nestling bald eagles produced in the GYE revealed mean total ChE concentration of 731.67 I*U*/L (N=9, ±79.05, $\alpha=0.05$) and mean acetylcholinesterase (AChE) of 192.39 I*U*/L (N=9, ±45.28, $\alpha=0.05$). Neither total ChE nor AChE concentrations were significantly different from corresponding concentrations in nestling bald eagles produced in Montana outside of the GYE. No correlation was found between total ChE and AChE concentrations in the 9 eaglets sampled ($r = 0.16$). A nestling bald eagle produced in the Centennial Valley of southwestern Montana (CM population unit) did exhibit clinically depressed[3] AChE concentration (57 I*U*/L), suggesting exposure to organophosphate or carbamate insecticides (Hill and Fleming 1982). One adult bald eagle recovered in 1989 in the SI was confirmed to have expired from the effects of organophosphate toxicity (J. Naderman, ID Fish & Game Dept. pers. comm.)

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[1] *1,1,1-trichloro-2,2-bis(*p*-chlorodiphenyl) ethane.*

[2] *1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene.*

[3] *Considered clinically depressed if 2 standard deviations below mean.*

Heavy Metals

Between May 1985 and August 1991, blood of 146 bald eagles was analyzed for heavy metals; 119 nestlings, 10 resident adults, 10 migrant adults and 7 newly fledged or immature eagles. All samples were obtained from eagles handled in the GYE. The adult male associated with the Schwabacher breeding area was captured and tested twice and both samples included in analyses. Overall, 34.9% had detectable levels of Pb, 91.4% had detectable levels of Hg and 100% had detectable levels of Se. Mean concentration ($\alpha=0.05$) of Pb, Hg and Se for all eagles tested was 0.17 ±0.16 , 0.49 ±0.12 and 1.56 ±0.24 ppm wet weight, respectively. Mean concentration of Pb and Hg detected (only eagles where respective metal was found) was 0.48 ±0.26, 0.53 ±0.13 ppm wet weight, respectively.

Table 51 illustrates detection rates and mean concentrations of 3 heavy metals by residency status and resident age group. Mean concentrations ($\alpha=0.05$) of Pb, Hg and Se for all resident eagles tested (including nestlings) was 7.13^{-02} $\pm 3.4^{-02}$, 0.403 ±0.11 and 1.59 ±0.26, respectively. Detection rate was 31% for Pb ($\bar{x}=0.23 \pm 9.7^{-02}$ detected concentration), 90.7% for Hg ($\bar{x}=0.444 \pm 0.12$) and 100% for and Se. Resident eagles that did not show detectable concentrations of Hg were all nestlings. Migrant adults had the highest proportion of all 3 metals, followed by resident adults, immatures then fledglings. Nearly all migrant bald eagles had detectable levels of Pb while less than half of resident adults did. Migrant eagles also had significantly higher mean Pb concentrations (P = 0.0002, Mann-Whitney test), 12.8 times those of resident adults. Migrant eagles and all resident eagles had equivalent concentrations of Hg but resident adults had Hg concentrations 1.3 times higher than migrants, but not significantly so. Resident bald eagles had Se concentrations over 2½ times as high as migrants (P = 0.017, Mann-Whitney test) with resident adults nearly 3 times as high. Considering only adults, migrants appeared heavily contaminated with Pb but residents relatively clean. The opposite was true for Hg and Se.

Table 52 shows detection rates and mean concentration of 3 heavy metals for nestling bald eagles produced in the GYE by population unit. Nestling eagles in population units with the highest detection rates were not necessarily those with the highest mean concentrations of respective heavy metals. Nestling eagles in ST had the highest detection rate for Pb but highest mean concentration (tested and detected) was in SW. Nestling eagles in SW, SI and YU had 100% detection rates for Hg and generally the highest mean concentrations. Se concentration was highest in CI and lowest in YU.

No distinct trends in mean heavy metal concentrations in blood of nestling bald eagles by population unit and year were evident (Appendix Figures 64-66), but Pb levels in 1986 appeared exceptionally high (Fig. 63). Se concentrations appeared to increase dramatically between 1986 and 1988 in nestlings, adults and immatures resident in the GYE (Figs. 63 & 64). Pb appeared to decline in migrant bald eagles between 1986 and 1988 while both Hg and Se increased but sample sizes were small (Fig. 65). Higher annual detection rates tended to be associated with lower mean concentrations of Pb and vice versa ($r = -0.605$, P = 0.15).

All bald eagles sampled had detectable levels of at least 2 heavy metals. Data illustrate the cumulative nature of heavy metals in resident eagles over time. Concentrations tended to be lowest in nestlings, intermediate in fledglings and immatures and highest in adults. Detected mean Pb concentration for nestlings was not significantly higher than resident adults and immatures and detection rate was slightly lower. When compared to other age classes of resident eagles, nestling Hg concentrations were significantly lower ($P<0.01$, Mann-Whitney test). All nestling eagles tested contained Se but concentrations were half that of other resident age classes and were significantly lower ($P<0.001$, Mann-Whitney test). Although Pb levels were similar in resident adults and nestlings, Pb was detected in more adults than nestlings. However, analysis of blood of the Schwabacher male from different seasons hints at variability in contaminant loads over time and within individuals (Table 54). Pb level was highest in winter when eagles would be exposed to waterfowl wounded or killed by lead shot. No Pb was detected in the sample obtained in summer. Hg concentration was higher in summer while opposite was true for Se.

Six eagles recovered in the GYE were diagnosed as having expired from Pb poisoning. Two were recovered in the SW (LSR & ST) and 4 in the SI. An additional eagle banded as a nestling in the GYE was recovered in southcentral Idaho and determined to have died from Pb poisoning. An adult male recovered alive at Moose Ponds in ST had a blood Pb concentration of 3.00 ppm (wet) and eventually died. One eagle recovered along the Snake River near Irwin ID and necropsied at USFWS National Wildlife Health Laboratory, Madison WI had a liver Pb content of 16.32 ppm wet wt. (case # 62 31-001). No eagles inspected or encountered were known or suspected to be suffering effects of Hg or Se toxicity, even though blood concentrations were elevated and occasionally quite high.

Disease, Injury and Parasites

In May 1986, an immature eagle fostered to Ford's nest in 1985 was found near South Park Bridge with an injured leg. One digit was absent suggesting entanglement in a leg-hold trap. Upon further veterinary inspection, the eagle was found to be suffering from gout and eventually died. In February 1986, an adult male bald eagle was found with an injured wing at Moose Ponds within the Moose pairs range. Attempts were made to repair the wing but were unsuccessful. It was unclear if the bird was a member of the Moose pair or a wintering migrant. However, the Moose pair did not produce the following season. An adult female was found covered with ice on Pacific Creek in GTNP in February 1987. Injuries were consistent with those from a leg-hold trap and wing, leg and foot damage was so severe the eagle was euthanized. Residency status of this bird was also unknown but she was probably a wintering migrant.

In May of 1987, a near adult female bald eagle was recovered on the levee along the Snake River in SP, at about the territorial boundary between Gill's and Ford's pairs. All primary feathers on the right wing were damaged and the eagle was severely emaciated. Several golden eagle secondary feathers had been imped in one wing, indicating she had been rehabilitated previously. Pied plumage pattern indicated the eagle was probably produced in SP. The eagle was rehabilitated, radio-tagged and released on the NER on 5 February 1990. On 7 August 1990, a fishing outfitter found her recently killed on an island in the Snake River in SI, sans transmitter. Carcass and plumage condition was good. Circumstances of recovery indicated she may have been killed in a territorial encounter with a resident adult bald eagle (D. Burgard pers. comm.). The carcass was sent to the USFWS eagle repository in Ashland OR by Idaho Fish & Game enforcement personnel and eventually dispersed to a Native American for ceremonial purposes. Idaho bald eagle study personnel failed to communicate their inspection of the carcass and actual cause of death was not determined.

One recently fledged bald eagle was found dead below the Butler Creek nest in June 1989. Feather development indicated the eagle was no more than 11 weeks old. Circumstances of the recovery indicated the eaglet had fledged prematurely and was killed and consumed by a large mammalian predator.

Between 1986 and 1989, 96 bald eagles of all age classes and population units were tested for the presence of hematozoa. Only 7.3% of those tested were positive, all were nestlings and all had *Leucocytozoan* spp. only. Of eagles testing positive, 3 were from different nests Idaho; 2 in CI (Sheridan Reservoir and Henry's Lake, both in 1987) and 1 in SI (St. Anthony, 1987). One nestling in the Eagle Bay nest (YU) in 1986 and both siblings in 1988 tested positive. A nestling in the Jardine nest (CM) in 1989 also tested positive.

Although no infestations of ectoparasites were noted, condition of the carcass of an eaglet found dead below the Jardine nest in 1989 suggested heavy infestation of simulid flies induced fledging prematurely. The eaglet apparently died in a fall while attempting to avoid the pernicious flies.

Movements, Habitat Use and Avoidance of Human Activity

Perching Habitat

Results of multiple regression analysis indicated stronger relationships with increasing site and time specificity of perch weight and CEM value. Summed weights of perches in an RMS determined for all seasons showed least correlation with respective RDI and CEM (Table 55). Correcting RMS perch weights used during appropriate seasons increased R^2 but relationship was still weak (Table 55). In each analysis, RDI was the best predictor of bald eagle use (high perch weight). Simple linear regression of perching CEM for SP and ST with perch weights of all eagles showed a moderately strong correlation (r = 0.425, Fig. 66). Analysis of perching CEM may be a fair predictor of eagle use.

Regression of time specific CEM, RDI and perch weights for the Schwabacher male showed the strongest and most significant relationship (Table 55). Higher perch weights tended to be associated with higher perching CEMs in areas of mid to high ranges of RDI (Fig. 67). Such relationships appear to be masked if only overall perch weights (for all seasons) or RMS seasonal perch weights derived from all diurnal monitoring hours are considered. RDI and respective CEM appeared adequate predictors of bald eagle RMS (or other habitat) use only for distinct periods when impacted, not all year long. Simple linear regression indicate perching CEM may be a fair predictor of respective seasonal eagle use. CEM was moderately correlated (r = 0.5829, P = 0.0014) with seasonal RMS weights (Fig. 68).

Foraging Habitat

Relationships of perch weight scenarios with foraging CEM and RDI were similar to those for perching CEM and RDI, only generally less strong. Again, RDI was a better predictor of perch weight than foraging CEM. Schwabacher male and Oxbow female seasonal perch weights were more highly correlated with CEM and RDI than other eagles (R^2 = 0.362). Sample sizes for these eagles however, were larger. Simple linear regression showed a moderately strong correlation (r = 0.421) of foraging CEM with seasonal perch weights for all eagles but P value was not significant. Analysis of foraging habitat remaining may not be a good predictor of eagle use.

Temporal and Spatial Avoidance of Human Activity

Bald eagles appeared to modify activity and movements to avoid encounters with humans. In the LSR, bald eagles appeared to avoid perches on the same side of the River as a heavily used state highway. Chi-square analysis of all perches identified in the LSR showed significantly more perches located on the side of the river opposite that of Highway 89/26 (X^2 = 58.9, df = 329, $P<0.001$). Large sample and significance suggests strong avoidance of vehicular traffic and associated human activity. Most perches also permitted view of the highway.

Movements of the Sheep Gulch male indicate an awareness and response to changing human activity levels on the Snake River. He often roosted with his mate upstream of the nest site, but left the roost in early morning to forage at the confluence of the Snake and Grey's Rivers. Recreational river traffic was high from initiation of radio-tracking until mid September. During this time, the pair would seldom venture upstream of the nest site prior to 1700 hrs. After 1700 hrs, virtually all river traffic was gone. The nest site was also less than 200 m downstream of the Sheep Gulch parking area where over 95% of all floats left the River.

The Elbow pair's primary use area was the most heavily impacted section of the Snake River in the LSR. Despite continuous and often highly intensive human use, the Elbow pair shifted their activity patterns in apparent response to periods when their presence would be least obvious to humans: very early morning and occasionally late evening. Both Elbow male and female were observed often perched atop a large spruce (*Picea spp.*) directly over the occupied campground! The perch itself was obscured by surrounding vegetation and foliage of the tree, both from the main highway less than 50 m away and even from campers directly at or near the base of the tree. The perch may have been less obvious to humans than those even on the other side of the river.

Although data were collected during 2 different years, correlations among percent of total perches within 10 m of the Snake River for the Cabin Creek male bald eagle and number of water craft per hour period suggest an avoidance of the river by eagles during periods of peak recreational use (Fig. 69). Characteristics of recreational river use appeared to change little between 1986 and 1987 in the LSR, although volume of users undoubtedly increased. Percent of total perches along the river was low during most of the day until about 1700 hrs. Number of watercraft on the river rose abruptly from dawn until 0900-1000 hrs., then declined. Watercraft were virtually absent from the river after 1700 hrs. Spearman rank correlation showed a significant, negative correlation between percent perches within 10 m of the river and mean number of watercraft on the river (r= -0.35, P = 0.009), per hour period. The Cabin Creek male, like the Elbow pair, used perches directly over an occupied campground. Use of the Cabin Creek campground was somewhat clandestine, as the Cabin Creek male would use perches only during very early morning (0430-0600 hrs) before campers had arisen.

Soon after young fledged, there was an abrupt shift in habitat use by the Schwabacher male. Use shifted from the Snake River near the nest site when he began using Taggart Lake and occasionally Bradley Lake. These areas allowed refuge from the continual float traffic on the Snake River. Although Taggart lake is a popular day use area by hikers, use is restricted to the north and east shores; the Schwabacher male used the west and south shores. The Schwabacher male returned to the Snake River after most of the commercial float activity had subsided (late September). He also moved north and used the Snake River below Snake River Overlook, 1/2 km south of a boat launch used frequently during summer but mostly inactive during September.

Corresponding to the decline of river use by watercraft, the Oxbow female began using the Snake River near Pacific Creek outlet and across from the boat launch near Moran Jct. Waterfowl frequented this area and foraging attempts on fish by the Oxbow female were observed. She continued to use the Oxbow area but began using the river 1 km downstream of Jackson Lake Dam when angling declined and the season closed.

In 1987, reconstruction work on Jackson Lake Dam began on 15 May. Prior to 15 May, the Third Creek female made several flights over the dam and continued down the Snake River. She also was observed perched on the shoreline of Jackson Lake within 1 km of the dam. After 15 May no perches within 1 km of the dam nor flights over the dam were detected. In 1988, after young fledged and activity at a borrow pit at the mouth of Third Creek began, the radio-tagged fledgling (099, Table 6) was not located within 1.2 km of the activity. The year before, the radio-tagged fledgling (393, Table 6) spent considerable time immediately post-fledging at the mouth of Third Creek. Movement by the family group to Moran and Bearpaw Bays was earlier in 1988 than in 1987, and coincident with borrow activity at the mouth of Third Creek.

Reclamation of the borrow areas at the mouth of Third Creek commenced on 11 July 1988. Prior to this date, the Third Creek male bald eagle frequented the nest area, spending nearly half the time monitored there. He also used perches on Hermitage Point, adjacent to the Third Creek borrow area. After initiation of reclamation work, the time in the nest area decreased and he did not return to the east side of Hermitage Point. He subsequently frequented Moran Bay and Half Moon Bay on Jackson Lake. The Third Creek male was again located, at the high water line, in the vicinity of Third Creek on 17 July, after reclamation at the outlet had ceased and activity moved east. After his progeny fledged (23 July 1988), he rarely visited the nest area, coincidentally increasing use of Half Moon Bay, while reclamation activity below the high water line progressed towards the dam.

Although data suggests toleration of human activity as close as 60-150 m from an occupied perch (n.b. Fig. 47, and Schwabacher male, above) an important consideration is that eagles were never observed *choosing* a perch within 100 m of human presence in direct view. Eagles apparently may tolerate *approach* of humans within as close as 60 m, but will seldom *select* a perch within 100 m of ongoing human activity.

Movements of Juvenile and Immature Bald Eagles

Twenty-one bald eagles were radio-tagged as nestlings (17) or recently fledged (4) between June 1985 and July 1989 (Table 6). Long range movements are shown in Appendix Figures. Nomenclature for identifying each bird includes natal nest site as shown in Figure 3 (except sites in Idaho and YNP), gender and year of radio-tagging. Type of transmitter and method of attachment are presented in Table 6. Each is referred to in subsequent narrative by kilohertz frequency of its transmitter (Table 6). Hence, a nestling male radio-tagged with frequency 148.600 mHz in the Sheep Gulch nest site in 1986 is referred to as 600. Movements are presented in chronological order based on date of radio-tagging.

Some eagles ranged throughout the GYE and were located in areas identified in the narrative but not shown in Appendix Figures. The reader is therefore encouraged to consult road, National Forest (Bridger-Teton & Targhee in Wyoming and Idaho, Beaverhead and Gallatin in Montana) and large scale National Park (GTNP and YNP) maps for orientation.

Moose Female 1985

A female nestling was radio-tagged with frequency 823 on 10 June 1985 at the Moose nest site. She was the oldest of 3 siblings and fledged about 25 June. Locations of 823 were within 200 m of the nest site until 10 September when the signal was not detected in the Jackson Hole area. On 15 September 1985, 823 was located along the Snake River in eastern Idaho, about 2 km downstream of Palisades Dam. This location was 56 km and 240-245° from the natal nest. 823 was not detected after 15 September 1985.

Dog Creek Male 1985

A male nestling was banded and radio-tagged with frequency 975 on 11 June 1985 in the Dog Creek nest. He was the oldest of 2 siblings and fledged before his sister the first week of July. Infrequent monitoring throughout July to early August always revealed 975 within 800 m of the nest site. In August, he often was observed soaring with his nest mates to the periphery of the adult home range. He once was seen soaring with a large stick, dropping and recovering it while airborne. Twice he was seen attacking a parent eagle and taking fish. On 16 September he soared well south and west of the adult breeding area, but had returned by 17 September. He remained in the adult home range until 8 October and was not detected again until the following spring. Post-fledging movements are illustrated in Appendix Figure 67.

On 26 April 1986, 975 was found on Palisades Reservoir. He was next detected in the LSR within the Elbow pair's home range (Fig. 22) in late April but had returned to Palisades Reservoir by 30 April. Aerial surveys throughout the GYE in summer 1986 failed to locate 975 from 1 May until 25 August 1986, when he was located within 200 m of the Butler Creek nest in SP. He remained along the Snake River in SP until 4 September when he was located in LSR within 100 m of his natal nest. From 4 to 7 September he moved throughout the lower LSR and then to the upper (south) end of Palisades Reservoir. There, he frequented areas also used by fledglings produced in both the Schwabacher and Sheep Gulch nests in 1986 in addition to at least 10 other young eagles. He was not detected in 1986 subsequent to 8 September, when he presumably left the GYE. While in SP and LSR, 975 was often perched near and occasionally next to another radio-tagged juvenile bald eagle, the Butler Creek female 1985 (see below). Regional movements of 975 in 1986 within the GYE are shown in Appendix Figure 68.

In 1987, 975 was detected only during early spring and autumn. He was first detected at the south end of Palisades Reservoir on 12 April and was tracked moving in a northwest direction. Now a subadult, 975 roosted that night near the Bear Creek arm on the northwest side of the Reservoir. The next day, the eagle continued moving north but the signal was lost northwest of Irwin, ID along the Snake River. Signal characteristics indicated the transmitter was functioning on solar power only. He was not located again that year until 6 September when found on the Snake River in SP between Moose and Wilson Bridge (Appendix Fig. 69).

975 was tracked only during spring in 1988. First located along the Gros Ventre River near the north end of the NER on 19 March, 975 then moved to the Snake River in GTNP near Snake River Overlook in the vicinity of the territorial boundary between Schwabacher and Triangle X pairs (Fig. 15). He then moved south along the Snake River through SP and LSR to Palisades Reservoir on 25 March, returning to within 200 m of his natal nest on the same day. On 28 March, he was located during an aerial survey on the Gros Ventre River, 1.6 km east of Kelly WY. He was next located on the Snake River in Idaho at the mouth of Burns Creek on 8 April. Long range movements of 975 in 1988 are shown in Appendix Figure 70. Errant signals were heard on Palisades Reservoir in spring 1989 but could not be verified.

Butler Creek Female 1985

One of 2 siblings in the Butler Creek nest, a female was banded and radio-tagged with frequency 700 on 11 June 1985. She fledged on 26 June 1985, about 3 days after her brother. Both possessed unique plumage coloration not previously noted in bald eagles (see Unusual Plumage Characteristics). From fledging until leaving the ecosystem in September, 700 was within the home range of her parents (Fig. 27).

700 returned to the GYE by 30 April 1986 when she was located on Palisades Reservoir and detected on 5 succeeding days until 23 May. On 30 May her signal was detected from the ground on Yellowstone Lake and triangulated to a position near Eagle Bay or the South Arm, a minimum of 132 km from her previous location. 700 was next detected on 25 August within 50 m of her natal nest and remained in SP until 8 September, often in close

association with another radio-tagged immature bald eagle, the Dog Creek male 1986 (975). After leaving SP on 8 September, 700 was next located on 10 September at Lake Alice in southwestern Wyoming. She was 48 km northeast of Bear Lake UT, at least 115 km south-southwest of her last location in SP. Over the next 3 days, southwest Wyoming, northern Utah and southeast Idaho were searched by air but 700 was not located. Appendix Figures 71 and 72 illustrate 1986 movements through out the GYE.

700 was located next on 10 May 1987 near Eagle Bay on Yellowstone Lake. Although 3 extensive aerial surveys were conducted during summer and autumn 1987 (Appendix Table 3), 700 was not located.

During a ground survey on 11 and 12 July 1988, 700 was triangulated to the vicinity of Flat Mountain Arm on Yellowstone Lake. On an 18 July aerial survey, she was on the south shore of Heart Lake in YNP. The last location of 700 in 1988 was on 23 July on Jackson Lake in GTNP. When located, 700 was in the home range of the Third Creek pair of bald eagles near Elk Island (Fig. 15). Appendix Figure 73 shows movements of 700 in 1988.

Between 4 March and 6 March 1989, 700 was reported on the South Fork of the Snake River in eastern Idaho near the confluence of Pine Creek. At this time, the radio signal was weak and intermittent indicating a failing transmitter. An adult bald eagle wearing a backpack transmitter was observed in the same location in 1990 but identity was not confirmed.

Cabin Creek Male 1985

A male nestling was banded on 24 June 1985 and radio-tagged with frequency 925 on 1 July at the Cabin Creek nest. He fledged prior to his sister about 10 July and remained within his parents' home range (Fig. 24) until 9 October, when he apparently left the ecosystem.

In 1986, 925 was not located. On 5 May 1987, 925 was detected within the Cabin Creek adult home range (Fig. 24) and triangulated within 200 m of the nest. He was detected later that day moving downstream towards Palisades Reservoir. He was detected on 11 August and 8 October again within 200 m of his natal nest.

In 1988, 925 was detected flying north at the north end of Palisades Reservoir on 1 April. He was next located on 3 April, farther downstream (north) on the Snake River, near the town of Swan Valley ID. 925 was observed next on 8 April in the vicinity of Burns Creek and Snake River, 20 km northwest of Swan Valley. Signals of frequency 925 were detected briefly within the Cabin Creek home range in autumn 1988, but origin could not be confirmed. 925 appeared to be investigating occupancy of the breeding area in spring and autumn up to 3 years post-fledging.

Ford's Male 1985

In late June 1985, USFWS Endangered Species Office, Helena MT inquired as to the feasibility of an orphaned nestling bald eagle recovered from Lake Mary Ronan northwestern Montana, being fostered to a nest of similar chronology in the GYE. On 26 July, a crude platform consisting of branches was built about 5 m below the Ford's bald eagle nest in the GYE containing eaglets of similar age. The orphaned eaglet was radio-tagged with a tail-mounted transmitter 575, banded with a USFWS band only and placed on the platform with 2 days of rations. The fostered eagle left the platform (fledged) on 29 July. Resident adult eagles were observed bringing prey to the fostered eagle on 3 occasions subsequent to fledging (H. Ford pers. comm.). Movements of the fostered eagle post-fledging were similar to those of other radio-tagged juvenile eagles in the GYE, however 575 ranged farther away from the Snake River and home range of his surrogate parents in early autumn than did other juvenile eagles tracked. These movements suggest adult home range may have extended well off the Snake River also, and included high country to the west. Off-river movements were coincident with presence of viscera piles left by elk hunters during early September. The fostered eagle left the GYE on 10 September, the same day as Moose Female 1985 (823) left her parents home range.

On 19 May 1986, 575 was found sans transmitter, wounded along the Snake River in South Park. The eagle had apparently encountered a leg-hold trap, lost a toe and injured tendons of the left leg, presumably struggling to free itself from the trap. Rehabilitation failed due to an overdose of anesthetic from which the eagle did not regain consciousness.

Cabin Creek Female 1986

A female nestling was banded and radio-tagged with frequency 500 on 14 June 1986 at the Cabin Creek nest. She fledged after her brother about 27 June and moved throughout the parental home range (Fig. 24), the adjacent Dog Creek home range, on downstream to Palisades Reservoir (Appendix Fig. 74) the rest of the summer. She made an extended pre-migratory flight about 60 km to the northwest on 6 September only to return to the natal nest site the same day. She left the ecosystem on 9 September 1986.

In 1987, 500 was first detected on 15 February on Jackson Lake in GTNP. She was not again located until 6 April when she was found at Oxbow Bend in GTNP, in the presence of at least 6 other juvenile and immature bald eagles. She remained in the Oxbow Bend vicinity until 3 May when she was tracked moving south through the western portion of GTNP to SP. The following day, she was located again at Oxbow Bend but on 5 May moved to the Snake River near Moose WY. On 6 May, she flew south to Wilson, WY then west over the mountains to Palisades Reservoir near Alpine WY. Over the next 2 days she moved back up the Snake River through LSR to near Wilson WY then to the foothills near Teton Village WY. Searches of Jackson Hole on 9 May failed to located her. She was next detected on 31 May on Henry's Lake in CI at least 118 km north-northwest of her last detected position but was not visually located. She remained on Henry's Lake through 8 June. During the latter days of that period, she was associated with as many as 20 other immature bald eagles catching fish in pools at the mouth of Targhee Creek at the east-southeast portion of Henry's Lake. She was next detected in the vicinity of the Southeast Arm of Yellowstone Lake in YNP on 2 July, but bearings were secured from the ground and exact location could not be determined. Minimum distance between those successive locations was 94 km. Her next location was at Deadmans point on Jackson Lake in GTNP on 27 July, 60 km from her last detected location. She remained on the Lake the rest of July. On 5 August 500 was found along the Snake River in SP where she stayed until 30 August. During her time in SP, she moved freely through resident adult home ranges of Gros Ventre, Ford's, Gill's, Butler Creek and Munger Mountain pairs, spending most of the time within the Ford's and Munger Mountain home ranges (Fig. 14). In afternoon of 30 August, 500 flew north along the Snake River to Deadmans Point on Jackson Lake. She stayed on Jackson Lake only 2 days and then moved progressively downstream along the Snake River, apparently orienting on many rafts of ducks in ponds, sloughs and channels. By 16 September, she had moved 2.5 km south of Moose WY. She was not located on 17 and 18 September, but on the 19th was found again on the Southeast arm of Yellowstone Lake, 85 km from her last detected location! From 20 September until 8 October, 500 was constantly moving. Her peregrinations took her from Yellowstone Lake to Heart and Shoshone Lakes in YNP to Hebgen and Quake Lakes in southwestern Montana. She spent from 25 September until 5 October almost exclusively on Hebgen Lake, moving among large waterfowl concentrations dispersed widely over the Lake. She spent much time associated with immense rafts of ducks in the Madison and Greyling Arms of Hebgen Lake. On 5 October, she left Hebgen Lake and moved to the Buffalo Fork of the Henry's Fork River near Mack's Inn, south of Henry's Lake, Idaho. The next day, she left the Henry's Lake Flat area in Idaho and flew *over* the Teton Range to the Snake River in GTNP near Snake River Overlook! She covered over 100 km in less than 3 hrs. She spent the next 2 weeks moving throughout ST and SP, again concentrating some activities in the Ford's pairs home range. On 18 October, 500 moved downstream along the Snake River, passing directly over and possibly perching near her natal nest. She continued moving downstream and west until her signal faded and was lost. The following day she was located by aircraft survey in the High Uintah Mountains on the Wyoming/Utah border. She had traveled over 270 km nearly due south in less than a day. Ground searches over the next 4 days failed to locate 500; she had begun her second autumn migration. Regional movements of 500 within the GYE in 1987 are shown in Appendix Figure 75.

In 1988, 500 was monitored only briefly. She was detected flying north along the Snake River in SP on 5 April, and spent until 8 April in the ST (Appendix Fig. 76). Although her signal was not heard for the remainder of 1988, aerial surveys and ground searches were much reduced from 1987. One brief signal was detected from 500 frequency near Hebgen Lake, Montana in early June 1989 but origin could not be confirmed.

Schwabacher Female 1986

The female of 2 siblings in the Schwabacher nest was banded and radio-tagged with frequency 411 on 16 June 1986. She fledged on 14 July after her brother but often was located back in the nest over the next 2 weeks. She remained within 800 m of the nest site until her signal was lost on 14 August. Errant signals infrequently detected throughout the remainder of August indicated she may have frequented high mountain lakes in the Teton Range, 9.2 km west of Teton Village WY. Several lakes are present in the vicinity of Moose Lake, 28 km southwest of the nest. These lakes may have provided respite from heat, recreational boat traffic and anglers on the Snake River while containing an adequate food base. Observations of her parents during the same time and during radio tracking of the Schwabacher adult male in subsequent years suggest 411's parents did not accompany her to the high country and the area was outside the adult home range (Fig. 30). 411 apparently became independent within 3 weeks of fledging.

The next confirmed location of 411 was on 3 September when she was detected soaring north of Wilson Bridge along the Snake River. She may have visited her natal nest site. The next day she was seen flying downstream along the Snake River in the LSR within the Sheep Gulch home range and was later found on the south end of Palisades Reservoir, along with other members of her cohort including 600 (see *Sheep Gulch Male1986*, below). Movements after 3 September are described in Bath (1987) (Appendix IV and shown in Appendix Fig. 85). She was eventually followed on her westward autumn migration through Idaho, Utah, Nevada, California and Oregon (Appendix Fig. 85).

In Oregon, 411's backpack harness became too small. She was observed in flight with one strap hanging, indicating she had literally burst out of the harness. She was captured and refitted with a tail mount transmitter (Bath 1987). 411 was obviously in excellent health, feather perfect and had gained at least 3 kg since radio-tagging in the nest. Her carina was barely evident when palpated. 411 was not detected after 31 October but the inherent ephemeral nature of tail mounted radios and her superb condition suggests 411 had molted the radio before returning to the GYE.

Ford's Male 1986

A male at Ford's nest site was hand captured on the ground on 6 July 1986. High winds the previous 2 days may have blown the eaglet out of the nest prematurely because feather development was consistent with eaglets only 9 to 10 weeks old. He was banded and radio-tagged with frequency 944. 944 was infrequently monitored until 15 August. He remained within 2 km of the nest site but seldom near the Snake River until early August when moved occasionally across the river to near the mouth of Fish Creek. Many ponds, sloughs, channels and spring creeks are dispersed through the flood plain in the vicinity of Ford's nest and many fishes, waterfowl, passerines and small mammals reside in or near them, providing an easily accessible food source exploited by both adult and young eagles. 944 was not detected subsequent to 15 August 1986.

Sheep Gulch Male 1986

The fledgling male from the Sheep Gulch nest produced in 1986 was captured with his paternal parent on 12 August 1986, less than 200 m from his natal nest. He was fitted with a tail mount radio transmitter of frequency 600. From capture to 27 August he ranged from the nest site downstream to Palisades Reservoir and was in almost constant association with at least one of his parents. The family group often was located perched near the confluence of the Snake and Grey's Rivers. Availability of waterfowl and fish was apparently high at the confluence as foraging attempts by adult eagles were observed there several times. Both 600 and his radio-tagged parent spent several days in a timber stand near the river confluence evidently consuming a large ungulate carcass. He also spent much time on the south end of Palisades Reservoir, often in the company of several other eagles of his cohort, including 411. On 27 August at about 1500 hrs, 600 flew off to the west-southwest. He was tracked traveling over Grey's Lake and Blackfoot Reservoir, Idaho until his signal was lost. Although much of eastern Idaho was scanned from the ground until dark, the signal was not detected. On 4 September, 600 was located in SP within the Butler Creek pair's home range (Fig. 27), at least 85 km northwest of where the signal was lost. He remained there until the afternoon of 5 September when he was tracked back to the south end of Palisades Reservoir, where 975 also was located. From 5 September until his signal was lost on 23 September, 600 ranged over Palisades Reservoir, LSR and lower portions of the Salt and Grey's Rivers (Appendix Fig. 78). He was not detected leaving the GYE but probably initiated autumn migration about 1430 hrs on 23 September.

Promontory Male 1986

On 8 July 1986, the male of 2 siblings of opposite gender in the Promontory nest in YNP was banded and radio-tagged with frequency 644. The Promontory nest was located on the northwest shore of "the Promontory", a peninsula between the South and Southeast Arms of Yellowstone Lake. 644 was located infrequently the rest of summer 1986 but always from the ground at least 15 km distant so accurate locations were not obtained. All bearings indicated 644 remained in the vicinity of the nest site, on both the South Arm and Southeast Arm and possibly Flat Mountain Arm on Yellowstone Lake. Date of departure from Yellowstone Lake is unknown but he was absent from YNP by early October 1986.

On 10 May 1987, 644 was detected near Yellowstone Lake in YNP but location was not determined. An aerial survey on 13 May 1987 located 944 in the vicinity of Bridge Bay in YNP. On 21 May 1987, 644 was located perched at Sand Point near Bridge Bay of Yellowstone Lake. The tracker walked within 25 m of the eagle and he appeared healthy and in fine plumage. Over the next week, 644 frequented a small stream near Lake Lodge.

Observers twice saw 644 and another colorbanded GYE immature in close association with a sow grizzly bear, which also was radio-tagged. In fact, the eagle and bear trackers met in dense forest wilderness following their respective animals! On 30 May the grizzly bear moved to Pelican Valley, 8 km away. 644 was next located in Pelican Valley on 31 May. Apparently, 644 (and other bald eagles) were following the bear! Two bearings secured in June indicated 644 was still in Pelican Valley. On 2 July, 644 was triangulated at the mouth of the Yellowstone River at the base of the Southeast Arm of Yellowstone Lake. During an aerial survey on 23 July, 644 was located near Elk Point on the northeast shore of Yellowstone Lake. He appeared to be up to 3 km inland and moving often, along the Clear Creek drainage. Clear Creek supports the largest population of spawning cutthroat trout in YNP (T. McEneaney pers. comm). During an aerial survey, on 12 August, 644 was located on the south shore of Heart Lake in YNP. On 7 September, 644 was located on the plateau west of Hawks Roost near Bridger Lake WY. On 19 and 20 September he was on the Southeast Arm of Yellowstone Lake and on 6 October again near Bridger Lake. The next day, 644 was detected in the Gros Ventre Mountain Range near the headwaters of the Gros Ventre River. He was not heard again in 1987.

In May 1988, 644 was heard briefly on Yellowstone Lake. Radio signal was erratic and weak, indicating a failing transmitter.

Gros Ventre Female 1987

Both sibling females in the Gros Ventre nest were banded and one radio-tagged on 23 June 1987. The radio-tagged eaglet's frequency was 196 and she fledged between 20 and 24 July. Until 26 August, 196 was always located within 1 km of her natal nest, occasionally in the nest and often perched with her parents on the west slope of West Gros Ventre Butte. She ventured upstream occasionally but was usually associated with the nest site. On 26 August she was located along the Snake River near the boundary of the Gill's and Ford's pair (Fig. 19), but was back in the nest area the next day. On 9 and 10 September she perched along the Snake River near Wilson Bridge and Ford's nest site. On 14 September, she was in the immediate vicinity of the Moose nest site. She subsequently was located in the area of her natal nest until 18 September when she was found on the southern end of Jackson Lake. She wandered extensively around Jackson Lake and visited Hermitage Point, Elk Island, Badger Island, Sheffield Island, Half-Moon Bay, Moran Bay, Colter Bay and Christian Bay. Her last location was on 9 October, still on the southern end of Jackson Lake. Movements of 196 are shown in Appendix Figure 79.

196 was located only once in 1988. On 5 April, she was located perched at the mouth of Beaver Creek on Heart Lake in YNP (Appendix Fig. 82). She was not located again.

Third Creek Male 1987

Two male siblings in the Third Creek nest were banded on 1 July 1987. The older male was radio-tagged with frequency 393, and fledged on or about 24 July. From fledging to 30 August, 393 remained in the vicinity of the nest site, and was located primarily along Third Creek. Figure 2, Appendix Vb shows perch sites used by 393 on Jackson Lake post-fledging. Reconstruction of Jackson Lake Dam occurred during the post-fledging period of 393 and borrow activities at the mouth of Third Creek may have influenced his initial movements away from the nest, i.e. he avoided the shoreline of Jackson Lake closest to the nest. He frequented Half Moon Bay, an area of shallow water and sequestered pools left by the receding waters of Jackson Lake, drawn down to facilitate dam reconstruction. In early afternoon of 14 September, 393 left Jackson Lake. He was located later that evening on the Snake River in eastern Idaho near the mouth of Pine Creek, north of Swan Valley ID. Distance from the nest site to Pine Creek area was a minimum of 70 km at an bearing of 240°. He continued farther, roosting on the shore of Ririe Reservoir, 24 km west of the Snake River. In less than 5 hours, 393 had traveled over 100 km. On 16 September, 393 again was located on the Snake River in eastern Idaho, this time moving among mouths of Pine Creek, Gormer and Dry Canyons. From 16 to 21 September he remained in the vicinity of Dry Canyon but in the late morning of the 21st, he flew to Island Park Reservoir, a minimum of 88 km north-northwest (≈350° from Dry Canyon). On 22 September, 393 was located in the South or Southeast Arm of Yellowstone Lake, as determined by triangulation from the ground at Lake Butte, YNP. In less than 2 days of movements, 393 covered a minimum of 185 km. 393 stayed on the Arms of Yellowstone Lake for only 2 days but when located again by aerial survey he was the Thorofare country along the Yellowstone River, southeast of Yellowstone Lake in YNP. He was next located on 29 September via aerial survey in the Wind River Mountains between Pinedale and Lander WY a minimum of 165 km south-southeast (≈150°) from his last location. He wandered among the west slopes of the Wind River Mountains frequenting Shoshone, Frye, Christina, Fiddler and Louis Lakes until 25 October. He was seen once near Frye Lake associated with an elk viscera pile. On 26 October, he moved to Boulder Lake, northeast of Big Sandy WY. He remained here until at least 6 November when monitoring ceased. Long range movements post-fledging are shown in Appendix Figure 80.

In 1988, 393 first was located by aerial survey on 6 May, 3.2 km northwest of Henry's Lake in eastern Idaho. On 25 May, signals of 393 were triangulated to southwest of Henry's Lake and on 16 June, he was located via air 3.2 km west of Henry's Lake. From 17 to 19 June he was located on Duck Creek, southwest of Henry's Lake. Rainbow trout (*Onchorhynchus mykiss*) and cutthroat trout were observed spawning in Duck Creek during radio tracking and Richardson's ground squirrels (*S. richardsonii*) were abundant. Domestic cattle (*Bovus spp.*) were also calving and subjective evidence indicated 393 may have been foraging on after birth or stillborn calves. On 20 and 21 June, 393 visited Upper Red Rock Lake in the Centennial Valley of Montana, just over the Continental Divide to the west of Henry's Lake but was back at Duck Creek in the afternoon of the 21st. He spent one day there, then returned to Upper Red Rock Lake. He was not located on the 26th but was located on Lima Reservoir and the Red Rock River below Lima Dam on the 27th. Waterfowl were abundant on the shallow lakes and streams of Red Rock Lakes NWR, Lima Reservoir and Red Rock River. On 29 June, he departed the Centennial Valley. Next located on 11 July, 393 was at Moran and Bear Paw Bays on Jackson Lake, a minimum of 155 km southeast (≈122°) of his last location in the Centennial Valley. He was resident on the south end of Jackson Lake until 26 July, using primarily Spalding, Moran and Bear Paw Bays. On 1 August, 393 was located on the north end of Jackson Lake, signaling a impending change in movements. He was not located the next day but was detected again in the Centennial Valley of southwestern Montana on Upper Red Rock Lake on 9 August! By 22 August, he had returned to the south end of Jackson Lake. He remained on Jackson Lake until 23 September again frequenting mostly Spalding, Moran and Bear Paw Bays. From 27 September until 30 November, 393 was not located although one ecosystem wide aerial survey was conducted in October and various portions of the GYE were searched from the ground. On 30 November, 393 was located in GTNP along Cottonwood Creek, south of Jenny Lake. Spawning white fish were available along Cottonwood Creek in autumn and 393 was apparently exploiting them along with several other immature and adult bald eagles. 393 apparently remained in GTNP until early December as he was located several times along the Snake River between Moose WY and the Oxbow and in the uplands until at least 2 December. An aerial survey of the GYE in mid December failed to detect 393. Regional movements within the GYE during 1988 are shown in Appendix Figure 81.

In 1989, 393 was detected along the Snake River in the Gros Ventre home range (Fig. 14) on 18 January and found along the Buffalo Fork River near Uhl Hill in GTNP on 27 and

28 January 1989. Both 393 and the Adult female associated with the Oxbow breeding area frequented these areas. Winter and hunter killed ungulates were noted dispersed in the vicinity and eagles seen feeding on carcasses. Although a GYE wide aerial survey was conducted in late March (Appendix Table 3), 393 was not detected. However, on 21 April he was found again on Duck Creek, west of Henry's Lake in Idaho! He had revisited the same area at about the same time as he did the previous spring. He was next located on Hebgen Lake in Montana on 24 April and 3 May. These were the last locations of 393. Considering movements and apparent health of 393, it is likely that lack of subsequent signal detections was a result of transmitter fatality rather than dispersal away from the GYE or death of the eagle. Movements of 393 in 1989 are displayed in Appendix Figure 82.

Munger Mountain Male 1987

The male of 2 siblings of opposite gender produced in the Munger Mountain nest was captured post-fledging on 6 July 1987. He had been banded previously as a nestling but was fitted with a tail mount radio transmitter of 260 frequency when captured. From capture until 10 August, 260 remained within 3 km of the nest site in SP but mostly within 100 m of the nest on the south shore of the Snake River. From 10 August until 13 September the location of 260 was unknown although much of the GYE was searched periodically by ground and air. Signals from 260 were next heard from Sawtelle Mountain in the Island Park area of eastern of Idaho on 13 September (Appendix Fig. 83). Direction was west, indicating 260 was in the Centennial Valley of southwestern Montana, probably near Upper Red Rock Lake. In fact in the late afternoon, 260 was observed on Upper Red Rock Lake. He was not located again in 1987.

On 31 March 1988, 260 was detected somewhere along the Snake River in SP, probably within the natal home range. On 4 April, he was heard on an aerial survey at Ririe Reservoir in eastern Idaho. On 25 April, 260 was located along the Snake River within the home range of Ford's adult pair (Fig. 14). Signals remained stationary for the next few days and no observations of an immature eagle in the vicinity were obtained. On 11 May, the transmitter was recovered; the tail feathers had been molted and the radio shed. On 7 July, 260 was recovered dead along the Snake River in eastern Idaho, north of Swan Valley. Cause of death was determined to have been gunshot wounds, delivered by a small caliber weapon. Enforcement action did not materialize. Known movements in 1988 are shown in Appendix Figure 84.

Box Canyon Female 1987

Two nestling eagles produced in the Box Canyon nest, located on the Henry's Fork of the Snake River north of Harriman State Park in eastern Idaho were banded on 24 June 1987 but the eaglets were determined to be insufficiently developed for safe attachment of a backpack transmitter package. The nest site was revisited on 3 July and the female nestling tagged with a radio transmitter of frequency 877. She fledged by 29 July and was within 400 m of the nest site each time located until 19 September. On that day she expanded her movements and was tracked moving among Bill's Island on Island Park Reservoir, Bishop Lake and the nest site. On 21 and 22 September, she was located west of the nest site along Thurman Ridge but on 23 September was again within 200 m of the nest. Last located via aircraft on 7 October, 877 was still within 400 m of the nest.

In 1988, 877 was first detected on 5 April in Island Park, Idaho, along the Henry's Fork River about 5 km southeast of Henry's Lake. She was also there on 5 May during an aerial survey. Although 2 aerial surveys of the northern half of the GYE were conducted in

June and July, 877 was not located. On 9 August however, 877 was found near the Yellowstone River in the Thorofare country of YNP, south of Yellowstone Lake. She apparently stayed in YNP for the remainder of the summer for she was located on the southern end of the South Arm of Yellowstone Lake in mid September and on the southern end of the Southeast Arm on 21 October. She was not located again in 1988 although several flights covering various parts of the ecosystem were conducted (Appendix Table 3).

In 1989, 877 was first located on 30 March in Island Park Idaho and again on 16 May. One aerial survey in late July failed to locate her but on 5 October 877 was detected near Rexburg ID. Aerial surveys of the entire ecosystem essentially ceased subsequent to that date and she was not detected again.

Antelope Male 1987

The male of 2 siblings of opposite gender banded on 9 June 1987 at the Antelope site on the South Fork of the Snake River in Idaho was fitted with a solar transmitter with frequency 827. Fledging date was not recorded and little post-fledging information is available. An aerial survey in early September located 827 near the nest site on the Snake River but was the last location in the GYE in 1987.

On 10 November 1987, 827's signal was detected from a hill 21 km west of Canby California, 50 km south of Tule Lake Sump. That night, he was triangulated to Mount Dome, a well known bald eagle roost (Lehman 1988), 22 km southwest of the town of Tule Lake CA. The next day he was located visually on the southern end of the Lower Klamath NWR, perched on a hillside overlooking Lower Klamath Lake. Many thousands (perhaps a million) ducks were congregated on the south end of the Lower Klamath Lake and he spent most of the day there. He roosted that night in the vicinity of the famous Bear Valley Bald Eagle Roost in Bear Valley NWR in southern Oregon, about 25 km northwest of Lower Klamath Lake. On 12 November he was again on the southern edge of Lower Klamath Lake, but was not monitored further in 1987. From 200 to 600 eagles commonly winter in the Klamath Basin.

On 18 July 1988, 827 was followed briefly flying south on the eastern aspect of the Elk Horn Mountains in west central Montana. Although not located visually, his flight path paralleled the western shore of Canyon Ferry Reservoir, an impoundment of the Missouri River 2 km to the east. Intensive habitat management for waterfowl on the southwestern end of Canyon Ferry results in production of many ducks, geese and pelicans. The Missouri River south of Canyon Ferry contains large populations of carp (*Cyprinus carpio*) and suckers. This was the only search for GYE eagles in Montana outside of the GYE and was the only summer location of 827 in 1988. He may have remained in the vicinity of Canyon Ferry Reservoir and the Missouri River all summer.

In November 1988, a receiver was sent to Tule Lake NWR and personnel scanned for GYE eagles. Again, 827 was located in the Lower Klamath Lake Basin along with another GYE bald eagle fledged from a nest on Yellowstone Lake in 1988 (see *Eagle Bay Male 1987*, below). Over 800 eagles congregated on the Klamath Lakes and Tule Lake in 1988, exploiting abundant waterfowl carcasses left as a result of a severe outbreak of avian cholera (*Pasturella multocida*) (J. Hainline pers. comm.). Personnel from the Alturas District, BLM followed both eagles but a report has never been received. Movements, duration of residence and departure date from the Klamath Basin of 827 therefore are not known.

In July 1990, a bald eagle in Basic III plumage (McCullough 1989) was observed along the Missouri River 8 km south of Townsend Montana. The eagle wore a GYE colorband consistent with that of eagles banded in the SI and a backpack transmitter. Although all frequencies of radio-tagged GYE eagles were scanned over several weeks, no signal was detected. The eagle apparently resided in the immediate area most of the summer due to the large number of molted feathers found below a perch and 3 subsequent sightings to mid August (Harmata 1991). In June 1991, and adult and near adult of distinctly dissimilar size (older bird smaller) were seen at the same location perched adjacent to each other. Distance and the desire to not disturb the pair prevented determination of presence of auxiliary markers on either eagle. It is likely that eagles were pioneering a new breeding area (Harmata 1991) and the marked bird was 827. Carp were abundant and available throughout summer in the area and large numbers of waterfowl winter in that section of the Missouri River (Eng 1991).

On 1 August 1991, field personnel noticed that an adult male bald eagle associated with the active Brown's Gulch nest near Hauser Lake, Montana wore a backpack radio transmitter. The transmitter frequency was identified as 827 on 6 August and the eagle confirmed to be the Antelope Male from 1987 by green over white colorband on the left leg on 9 August (Restani and Harmata 1992). The pair fledged 2 young in 1991 (one radio-tagged with 148.409 mHz). From August to October, 827's transmitter signal was intermittent and often weak and the radio eventually failed by mid October 1991. It had functioned for over 4 years.

Although 827 occupied the breeding area in 1992, the nesting attempt failed. Several subsequent observations of the adult male associated with the Brown's Gulch nest from April through autumn 1992 indicated the resident male did not wear a backpack transmitter although he used the same perches as 827. On 1 October, the male was finally observed at close range and determined to be 827 by presence of the colorband. He had shed the "permanent" backpack transmitter and harness about 4.5 years after attachment.

Eagle Bay Male 1987

On 15 July 1987, the male of 2 siblings produced at the Eagle Bay nest site on Yellowstone Lake in YNP was tagged with a transmitter of frequency 923. The eagle was intermittently monitored from the ground at Lake Butte in YNP, 15.5 km northeast of the nest. Distance and intervening lake prevented determination of fledging date and immediate post-fledging movements but by early August, bearings indicated 923 was moving up to 9 km from the nest, possibly as far as Flat Mountain Arm and The Promontory. On 7 September, 923 was still on Yellowstone Lake near the nest site but on 10 October he was located near Soda Springs, Idaho. He was obviously beginning his first autumnal migration.

On the first aerial survey in spring of 1988, 923 was located on Upper Red Rocks Lake in southwestern Montana. By 6 May he had moved to Henry's Lake Idaho and by mid June was located near his natal nest on Yellowstone Lake. During subsequent aerial and ground surveys, 923 was located mostly in the South East and South Arm of Yellowstone Lake (Appendix Table 3). He was last located in the GYE in 1988 on the west shore of the West Thumb of Yellowstone Lake on 21 October. In November, 923 was located on Tule and Klamath Lakes in northern California and southern Oregon along with 827 (see *Antelope Male 1987*, above). He remained in the Klamath Basin until mid December (G. Golet pers. comm.) and was not located again in 1988.

On 30 March 1989, 923 was located near Fishing Bridge on the Yellowstone River in YNP. On 14 April, he was seen (colorband and backpack observed: T. McEneaney pers. comm.) farther downstream on the Yellowstone River near LeHardy Rapids. Cutthroat trout are abundant in this section of the Yellowstone and it is world renown by anglers. By 24 April, 923 was on the south shore of Yellowstone Lake near Breeze Point. On 12 May, 923 was located and watched on Holmes Point on the southeast corner of Mary Bay. Proximity allowed close inspection of plumage, bands and transmitter package. All were in excellent condition. As in 1988, 923 spent most of the summer in the South and Southeast Arm of Yellowstone Lake. Periodic aerial and ground checks located him mostly at the mouth of the Yellowstone River on the Southeast Arm and Outlet Creek on the South Arm. On 5 October, 923 was located on West Thumb, indicating he may have been in the initial stages of his second autumnal migration. Subsequent ground checks around Yellowstone Lake failed to detect 923.

On 25 February 1990, 923 was located in Bear Valley NWR, roosting 3.2 km southeast of Worden in southern Oregon. He was located on 2 successive days until 28 February. Monitoring ceased on 29 February through 3 March and when resumed on 4 March no signals were detected. Timing of locations suggest 923 may not have wintered in the Klamath Basin as in 1988 but visited during migration. Waterfowl mortalities from avian cholera had dropped significantly in 1990 and fewer eagles were present overall (J. Hainlein pers. comm.). Long range, migratory movements of 923 are shown in Appendix Figure 85.

Hoffman Female 1987

Three siblings in the Hoffman Point nest on the southwest shore of Palisades Reservoir were banded on 19 June 1987. On 4 August, a recently fledged female from that nest was captured and fitted with a tail mounted radio transmitter of frequency 875. She remained in the vicinity (within 2 km) of the nest site from radio-tagging until 26 August when she was located at the outlet of the Snake River, east of the nest. She moved between these areas until 6 September, the last location on Palisades Reservoir. On 11 September she was located on Grey's Lake, a minimum of 31 km west-southwest of Palisades Reservoir. This movement indicated she was initiating her first autumnal migration from the GYE. 875 was not detected again, probably because she wore a tail mounted transmitter which may have molted prior to returning to the GYE in 1988.

Third Creek Male 1988

The lone male nestling in the Third Creek site on Jackson Lake in GTNP was banded and radio-tagged on 28 June 1988. Frequency of the transmitter was 099. He fledged about 24 July and remained within 400 m of the nest until 22 August. During that time he occasionally was seen on Second Creek and near the outlet of Third Creek. In late August, 099 began ranging farther and moving often over the southern half of Jackson Lake. Between 24 August and 1 September, 099 moved among the nest area, Half Moon Bay, west shore of Hermitage Point, Donoho Point, and the west shore of Moran Bay, often returning to the nest site. On 1 September, 099 was gone from Jackson Lake. Next located by aerial survey, 099 was at the mouth of Palisades Creek on the Snake River near Irwin ID. Between 6 and 8 October and again on the 13th, 099 was located near Conant Valley and the mouth of Pine Creek on the Snake River in Idaho, 8 km northwest of Swan Valley, ID. On 1 November, 099 was located back in GTNP on Cottonwood Creek south of Jenny Lake. He remained here with several other adult and immature eagles until 15 November, occasionally visiting Jenny Lake. Spawning whitefish were abundant and available and eagles were seen obtaining fish by merely walking in shallow water. On the 15th, 099 was detected departing Jackson Hole, however he had returned by 30 November when he was located on the Snake River in GTNP near Glacier View Overlook. Between 1 and 9 December 099 was observed feeding on ungulate viscera piles in GTNP and NER. He was tracked moving along the Gros Ventre and Snake Rivers and was once located 1.6 km downstream of the Munger Mountain nest site. On 10 December no signal was detected in the SW. 099 had left the GYE in the p.m. of 9 December.

099 returned to the GYE by 30 March 1989 when he was located on the Falls River, 5.6 km southeast of Ashton ID. By 28 May he was in the foothills northwest of Henry's Lake ID, the area 393 frequented in 1988. On 24 July he was on the West Fork of the Madison River in southwestern Montana, west of Wade Lake. On 25 September, he was in Moran Bay on Jackson Lake in GTNP but by 30 September was absent from the GYE. In 1991, 099 was detected at Henry's Lake in Idaho in early May. Movements of 099 in 1989 are shown in Appendix Figure 86.

Schwabacher Male 1988

The lone male eagle produced in the Schwabacher nest on the Snake River in GTNP was not banded as a nestling due to inaccessibility of the nest in a dead tree. He was captured with a radio controlled power snare on 10 August and fitted with a tail mounted transmitter of frequency 338. He remained in the vicinity of the nest for the rest of the week but on 16 August was located at Oxbow Bend. He was not located again until 9 September when he was found in Dry Canyon, a stream peripheral to the Snake River in eastern Idaho, about 16 km northwest of Swan Valley. The last location of 338 was on 16 September when he was found at the mouth of Palisades Creek on the Snake River, 5.6 km downstream of Palisades Dam. Lack of locations in 1989 was probably due to molt of tail feathers supporting the transmitter outside of the GYE.

Jardine Male 1989

A male recovered on the ground below the Jardine nest in Bear Creek in southern Montana 2 km south of Jardine was banded and tagged with a transmitter on 11 July 1989. Radio frequency was 011. 011 had apparently fledged prematurely due to heavy infestation of Simulid flies or high winds blowing him out of the nest. A dead sibling female was also located below the nest. A platform of large sticks was constructed in a large Douglas-fir, 150 m south of the nest. The platform was about 3 m off the ground and 011 was placed there with several whitefish. 011 fledged from the platform 2 days later. After 011 fledged, the parent male was observed several times feeding on whitefish carcasses placed on the platform. Although 011 was monitored intensely for the next month, little data on behavior or movements were recorded, partially because his activity area was obscured by vegetation and proximity that permitted observation would have been disruptive to the fledgling and resident adults. His last location was at the confluence of Bear Creek and the Yellowstone River on 13 August. By late August, no signal from 011 could be detected and he was never heard nor seen again.

Elbow Female 1989

On 10 May 1989, the adult male at the Elbow nest died in the bownet. Two eaglets in the nest were about 3 weeks old. Subsequently, the adult female was the lone provider for the brood so fish carcasses were floated past her to supplement her diet. She took several but ignored most, still successfully raising 2 healthy eagles. The brood was banded on 27 June and the female sibling fitted with a solar powered transmitter of frequency 412. She fledged after he brother between 13 and 15 July. For the next 2 weeks several observations indicated she had difficulty flying, but by 30 August, she was flying and behaving normally. The last location in the GYE in 1989 was on 6 September. She was never located farther than 600 m from the nest.

412 was next located by air on the east shore of Ririe Reservoir on 2 November 1990. She was apparently initiating her second autumnal migration.

Her second vernal migration ended abruptly. On 10 March 1991, 412 was found dead below a power pole just east of Coalville UT, 55 km east of Salt Lake City. Obvious burn marks indicated she had been electrocuted. When she was killed, she weighed 4850 grms and was in excellent plumage and health.

Use of South Park by Juvenile and Immature Bald Eagles

Throughout monitoring of adult resident bald eagles in SP, movements and habitat use of juvenile and immature bald eagles were noted. Perches and use areas of radio-tagged juvenile and immature bald eagles are shown in Appendix Figures 87 - 97. Perch areas of nonradio-tagged juvenile and immature bald eagles are shown in Appendix Figure 98 for RMS 31-33 and Appendix Figure 99 for RMS 37-42. Perch sites were consistent with those of resident adults but no agonistic encounters between adults and nonadults were observed. Foraging sites of juvenile and immature eagles were also similar to those of adults (Appendix Fig. 100). Use of South Park was greater during mid to late summer then shifting to areas where waterfowl were concentrated (Oxbow and bays of Jackson Lake in ST) or areas of large whitefish spawning runs (LSR at Dog Creek and Bailey Creek and Cottonwood Creek in ST).

DISCUSSION

Population Dynamics

Reproduction of bald eagles nesting in the GYE, especially the Snake unit of Wyoming, appeared adequate to maintain an increasing population from 1978 to 1990. However, not all segments of the GYE bald eagle population produced well (Swenson et al. 1986). The YU, especially eagle pairs in YNP, chronically produced poorly, well below levels established to maintain populations (Sprunt et al. 1973). However, number of occupied nest sites in YU remained remarkably constant for over 30 years, suggesting recruitment may come from outside of the YU or breeding adults had extreme longevity. Movements of juvenile and immature bald eagles radio tagged as nestlings in the GYE showed virtually all visited Yellowstone Lake at least once, some often over several years. Non-breeding eagles from all population units in the GYE used YU, indicating additional recruits most likely were provided by more productive units outside of the YU, most probably coming from SW. In addition to providing recruits to other population units in the GYE and other external regions (i.e. western Montana), the presence of unique pied plumage and band encounter data suggest recruits to the SU of Wyoming are provided primarily from within.

The remarkable similarity of the atypical plumage and talon coloration among several individual bald eagles in the GYE suggests a genetic rather than environmental etiology. Talon coloration was consistent with albinism (n.b. Austing 1965), but the similarity of atypical white feather pattern among nestling bald eagles was not indicative of partial albinism. Portions of the cere and mandibles bordering the affected plumage of nestlings were bright yellow rather than white or the normal black or dark brown. Additionally, the affected feathers were either completely white or completely black or dark brown, not diffuse or diluted with white, further indicating a non-albinistic condition.

Atypical plumage coloration of bald eagles described herein is most similar to a genetically based pied plumage described for domestic chickens (Punnet and Pease 1927) but is also present in some wild birds [e.g. black-billed magpies (*Pica pica*)]. Pied plumage was most obvious in eagles in juvenile plumage and may be partially or totally masked by successive immature and adult plumages. White crowns and chins would probably be masked in basic plumage (McCullough 1989) when viewed at a distance and certainly masked in definitive plumage. All eaglets noted with pied plumage had white breast and/or abdominal feather patches, but only 2 had white epaulets that would be evident in definitive plumage. If adults are not examined closely, white breast patches could easily be confused with molt or fouling and white epaulets confused with patagial tags. In fact, there have been reports of adult bald eagles with white wing tags in the northern Rocky Mountain region that could not be confirmed (R. Rau, D. Hinckley, B.R. McClelland pers. comms.). Confusion and unfamiliarity of pied plumage in bald eagles by both professional and lay observers may explain absence of previous documentation.

The proximity of nests and individuals exhibiting pied plumage suggests a possible close genetic relationship among nesting bald eagles along the Snake River in the GYE. Except for one instance in eastern Idaho, eagles exhibiting pied plumage appear to originate from the Snake River in northwestern Wyoming. Interestingly, in 1987 a fledgling radio-tagged in the Munger Mountain nest (Fig. 5, Site C) dispersed within 1 week and was subsequently located less than 5 km from the nest in Idaho where a pied eaglet was produced the following year. Radio-tagged immatures originating from affected nests in Wyoming have all visited Henry's Lake, less than 2 km from the Idaho nest.

Encounters with banded eagles further support the hypothesis of close genetic relationships among breeding bald eagles in the GYE. Two male eagles originally banded as siblings in 1980 in a nest on the Snake River in Wyoming (Fig. 5,Site G) initiated new breeding territories, one in 1986 and one in 1987. Both territories were also on the Snake River in Wyoming (Fig. 5, Sites H & I), 28.5 and 30.8 km from the natal nest. Range boundaries determined by radio tracking were adjacent to one another. It appears that recruitment to the expanding GYE bald eagle population was primarily from eagles produced within the ecosystem and at nest sites in close proximity to natal nests.

The most productive unit of the GYE was the SU (GYEBEWT 1983). In more recent years, population curve in SU of Wyoming appeared to level off (Fig. 3). Considering spacing between occupied nest sites (Fig. 1), the population may be reaching carrying capacity both from a habitat and behavioral (territorial) perspective.

Differences in reproductive phenology in SU of Wyoming apparently were a function of weather. Topographical and meteorological conditions are similar throughout the SP, which was the smallest in area and length of all areas in SU of Wyoming defined. Greater areas of LSR and ST included more diversity of weather and terrain, possibly influencing greater variability in nesting initiation times, duration of incubation and nestling growth rates.

Bald eagle productivity in SU of Wyoming was high (1.17 young produced per occupied site) over 5 years of study (1985-1989) with 193 eagles fledged. Although recent bald eagle population trends and productivity indicate no problems from a population health perspective, burgeoning human population and urban development trends and their effects on continued maintenance of healthy populations is of serious concern.

Breeding pairs in SP comprised only 32% of total for SU of Wyoming but produced over 38% of young (Table 17). Breeding pairs in ST comprised 42% of total but produced only 30% of young. The most productive portion of the SU of Wyoming was also potentially most threatened. No bald eagle nest sites are on public land in SP and therefore are subject to development, whereas virtually all in ST are on National Forest or GTNP administered land. Overall, only 7 of 21 eagle pairs (33%) in the SU of Wyoming produced 64% of the young.

Speculation on low productivity and its effect on population maintenance in YU (Swenson et al. 1986) did not consider high survival rates of young bald eagles. Survival rates determined during this study were highest of all reported for bald eagles (Table 20). Low productivity of YU eagles may be compensated by very high survival of the few eagles produced there or recruitment of "excess" eagles produced in the SU of Wyoming. Indeed, high-quality summer habitat in YNP may promote survival of immatures, not only from GYE but also other populations such as central Arizona and coastal Texas.

Survival of older immatures dropped between 2 and 3 years post-fledging. Indeed, few 2-year-olds and even fewer 3-year-olds were observed throughout the study. Survival of eagles from 3 to 4 years post fledging increased. Eagles in their second and third year may have tough times. After 1 year of age, plumage of immature eagles changes. Adult eagles, upon which juveniles are somewhat dependent up to 1 year, are much less tolerant of eagles with plumage more similar to their own. Yet foraging and hunting capabilities of older immatures may not be adequately developed for full in independence, hence survival drops. Those eagles that adapted or were educated sufficiently then have a greater probability of survival as age increases.

Most likely, survival rate indicated by detection rates of radio-tagged immatures was absolute minimum. Failure to detect eagles was probably more a function of incomplete survey coverage or transmitter life rather than eagle deaths. Some immature eagles wearing non-functioning backpack radios were observed and mal- or non-functioning transmitters were recovered from recaptured adult eagles. Considering the immensity of the GYE, relatively small area scanned on any one survey mission, mobility of eagles and propensity of returning eagles to continue to other regions make the number of eagles actually detected truly significant. In fact at least 3 immature eagles of GYE origin were observed alive in Montana outside of the GYE in spring or summer.

Band encounter rate was high (9.4%) relative to most eagle studies (approx. 3%: Bird Banding Lab. data), but did not necessarily indicate higher mortality in the GYE eagle population. GYE eagles are associated with lentic and lotic environments situated in an areas of North America where human and eagle populations are most proximate and in regions well known for recreational fisheries. This probably increases potential for encounters as reflected in rate. Although rate was higher, causative agent proportions (Table 14) of GYE eagles were similar to those of eagles in other areas of North America. Most eagle mortalities in North America were from anthropogenic causes with gunshot deaths the primary agent (USFWS, National Wildl. Health Lab., Madison WI). Gunshot deaths were also high in GYE but may just indicate percent of man-induced mortalities rather than overall mortality. Eagles most likely to be shot (i.e. near houses and roads) also most likely would be encountered. Highest proportion of GYE encounters were of unknown causes, most of which were probably from starvation, nonhuman related accident and interspecific aggression.

Disease, injury or parasites did not appear to be affecting survival of GYE bald eagles excessively. A few instances of mortality of nestlings were noted but overall fledging success was high and to 1991, nestling mortality was insignificant from a population stand point. Adoption of regulations encouraging anglers to retrieve all discarded fishing line may prevent future nestling deaths.

A disturbing trend of organophosphate or strychnine induced mortality of eagles throughout the northwestern states manifested in the late 1980's and early 1990's (Henny et al. 1987). At least 3 GYE eagles were killed from secondary poisoning by ingesting contaminated ground squirrel carcasses or laced ungulate carcasses presented specifically to kill predators. Documented mortality of 9 eagles at one carcass occurred in Montana (USFWS, Helena, MT) and rumors of similar wide scale poisoning in eastern and central Montana abound. Current methods involve distributing domestic livestock or wild ungulate carcasses laced with organophosphate (Diazinon, famphur, malathion) and/or carbamate (carbaryl, carbofuran) insecticides mixed with ethylene glycol (automotive antifeeze) around pasture borders. The practice may present up to 8 carcasses per square mile. Such indiscriminate predator poisoning in livestock producing areas of the west may be significantly impacting (or totally preventing) pioneering of new breeding areas throughout the west, affecting recovery of bald eagles. Timing of poisonings suggest migrant eagles are most severely affected but at least one nestling eagle produced in the GYE [Corral Creek breeding area (CM)] had depressed levels of acetyl cholinesterase in blood, suggesting exposure to anticholinergic compounds. More emphasis on education, research on alternative methods of predator and livestock management and aggressive enforcement and prosecution of offender should be initiated.

GYE eagles encountered leg-hold traps set for furbearers. In most instances affected eagles were thought to be migrants relatively unfamiliar with the area but one was an immature fledged from a nest in SP. In Colorado, 3% to 10% (depending on year) of all wintering *adult* bald eagles captured had one or more digits absent, most likely from encounters with leg-hold traps set for furbearers (Harmata 1984). As eagle populations increase, more and more eagles will encounter leg-hold traps. Current regulations are adequate for minimizing leg-hold trap injuries to eagles, but apparently few fur trappers adhere to visitation schedules and exposed bait restrictions. Enforcement is lax, especially in remote areas. Increased emphasis on education and enforcement could reduce eagle-trap encounters.

Incidence of *Leucocytozoon* infection in GYE eagles was low but Eagle Bay nest site in YNP appeared chronically affected. *Leucocytozoon* is transmitted to birds by simuliid flies (Greiner and Kocan 1977) usually associated with wetlands. Wetlands and standing water conditions existed more around the Eagle Bay nest site than other nest sites of eagles tested in YNP. Similarly, other eagles testing positive for *Leucocytozoon* were at lake nest sites, i.e. in habitats more likely associated with wetlands. One eagle testing positive for *Leucocytozoon* was produced at a nest in a lotic environment but the site was in a section of Snake River with a wide flood plain and therefore more likely associated with slow stream flows and standing water. Another lotically associated site where an eagle tested positive for *Leucocytozoon* (Jardine) was known to be infested with simuliid flies. In fact, one nestling mortality was attributed to premature fledging as the eaglet attempted to gain respite from excessive infestation.

Leucocytozoon has been documented in some raptor populations (Stabler and Holt 1965, Kocan et al. 1977, Tuggle and Schmeling 1982), but pathogenicity of infection is unknown. Very little work has been done on blood parasites of raptorial birds but *Leucocytozoon* spp. are responsible for high mortality rates in waterfowl (Herman et al. 1975, Julian and Galt 1980). In fact, *Leucocytozoon* spp. have been pathogenic in some raptors (Keymer 1972) and a athero-sclerotic effect is suspected. Breakout of the organism from cell walls may lead to excessive scarring, severely restricting blood flow resulting in arterial hemorage (R. Espinosa pers. comm.). Several instances of mortality from strokes in bald eagles have been noted (N. Thomas, Natl. Wildl. Health Lab., Madison WI, pers. comm.). A synergistic effect of pathogenic organisms and Pb contamination is suspected also (Reiser and Temple 1981) but few data are available for wild populations.

Determination of Home Range

Above the 50% level (Fig. 16), increasingly larger amounts of monitoring time are needed to add decreasingly smaller amounts of area to the home range polygon. This implies continued allocation of resources to monitoring beyond this point may be inefficient. Calculation from the above regression formula indicates approximately 397 hrs of monitoring time were required to delineate 50% of bald eagle home ranges in SU of Wyoming. Fifty percent of the home range may be considered representative because use was concentrated there (see Nesting History, Home Range and Use Areas of Bald Eagles, below).

Five radio-tagged eagles were monitored approximately 400 hrs (Cabin Creek male, Schwabacher male, Oxbow female, Third Creek male and Wilcox Point male). Sheep Gulch male and Butler Creek female were monitored considerably less, 274 and 168 hrs, respectively. Greater monitoring time for these eagles would probably have only increased area size away from the Snake River and not have changed delineation of area used on the River. River use was consistent and predictable and therefore range polygons were representative of River area included in the home range. Use of the Snake River by the Butler Creek female was highly restricted by the presence of adjacent territorial pairs. Greater monitoring time likewise would have added little or no additional river area to the home range polygon.

Home range polygons were poor indicators of important use areas within eagle ranges. Clearly, eagles concentrated activities along shorelines of aquatic areas as shown by distribution of locations within each home range polygon (Figs. 21 - 35). Much of the area within polygons was never visited nor overflown by eagles. Additionally, flights of resident eagles apparently patrolling the boundaries of the home range were not included. If the extent of these flights were included, home range size would be increased as much as 3 times, especially for Sheep Gulch, Dog Creek, Hoback and Butler Creek. For instance, the Butler Creek female completed one flight ranging 20.8 km north of the home range and returned without perching.

Seasonal Movements

Radio tracking and band encounters of juvenile and immature bald eagles produced in the GYE indicate virtually all leave the ecosystem the first autumn post-fledging. Ostensibly, juveniles need not leave the GYE. Juvenile eagles originating in Canada winter within the GYE indicating requisites for survival of at least some juveniles were present. Regardless, survival of immature eagles leaving the GYE during winter has probably been higher than those that did not, resulting in a population with a genetic propensity to migrate as immatures. Once initiated, both deterministic and stochastic components may have dictated timing, direction, rate of movement and destination of initial migration. Unlike juvenile migrants from Canada which may also be affected by proximate ecological factors (Harmata et al. 1985), genetically induced responsiveness to photoperiodic cues may have been primarily responsible for initiations of migration of GYE eagles. GYE eagles left their natal areas well before food resources dwindled or became unavailable due to snow cover or ice. In fact, waterfowl numbers in the GYE actually may have been at peak when young eagles departed. Once initiated, orientation was primarily southwest to the Snake River plain in Idaho and northern Utah, then west to the coastal states of the Pacific Northwest.

After initial compass direction was determined, responses of GYE eagles to stochastic events most likely dictated exact route and timing of migration since parental guidance was obviously lacking and migration was solitary. Physiography and meteorology modified orientation and migration, while rate was dictated by chance encounters of locally abundant food, adequate roost sites and optimal flying conditions. Presence of 2 GYE immature eagles on 2 subsequent years in the Klamath Basin of Oregon and California coincident with large die-offs of waterfowl supports the theory. Apparently both birds encountered the area, either by watching other eagles (McClelland et al. 1982) or by chance, returning the following year with the guidance of memory. The somewhat unusual longitudinal migration pattern (as opposed to the more common latitudinal avian migration pattern) and eventual destination of GYE eagles was consistent with the theory of genetic memory; eagles were homing to regions of historical abundant salmon runs of the Pacific Northwest (Hunt et al. 1992). Close genetic relationships among eagles within the GYE and with eagles produced in the Pacific Northwest lends strong support to the theory.

Considering genetically based propensity for GYE eagles to migrate longitudinally and west, care should be taken when selecting donor populations for reintroduction (hacking) efforts. Donor populations chosen should exhibit migration patterns most consistent with those of recipient populations. At least availability of adequate winter habitat at appropriate distance and direction as dictated by donor population movements should be considered. It may be ill advised, for instance, to use GYE eaglets for reintroduction efforts in coastal California. They may end up in Hawaii.

Upon arriving on the West Coast, timing of available encounters suggest juvenile eagles wandered the coast, ranging from Los Angeles in the south to Puget Sound in the north, possibly "looking" for extinct salmon runs. Homing immature eagles from the GYE may have been searching for vacant nest sites or incomplete pairs as virtually all visited their natal nest areas in spring. Subsequent to investigating natal nests, juveniles then dispersed throughout the ecosystem, essentially defining its limits. Young eagles radio-tagged in all population units were detected in all other population units at least once, seasonally exploiting mostly lentic habitats and associated spawning runs or waterfowl concentrations. Immature eagles apparently moved freely among nesting and non-nesting habitat of adult bald eagles throughout the ecosystem. As autumn approached, immature eagles moved gradually back towards their parent's territories, often as close as a few hundred meters from their natal nest. Such movements again may represent investigations of occupancy of territories for potential future nesting, indicating recruitment and pioneering in bald eagles occur primarily in spring and fall.

During summer, radio-tagged juveniles and immatures were regularly located throughout the GYE but rarely located on waters considered bordering or outside of the GYE. Few surveys were conducted outside of the GYE but the majority of eagles radio-tagged were in fact located within it, indicating surveys outside would have a low probability of success in locating missing eagles. Thus, movements and habitats used by these eagles may indicate real boundaries of the GYE and reinforce the importance of maintaining a large, continuous, intact ecosystem.

Immature eagles were found primarily on lakes within the GYE although the Snake River as well as smaller rivers and creeks throughout the ecosystem received periodic use by concentrations of immatures. Young eagles seemed to quickly key in on temporal concentrations of prey and carrion and regularly were found either along water bodies where fish were spawning (i.e cutthroat trout in YNP and Henry's Lake, ID in spring and whitefish in Cottonwood creek in GTNP in autumn) or areas where ungulate viscera piles left by hunters were available (n.b. early elk hunts in Jackson Hole and late elk hunts in GTNP and near Gardiner MT). Some areas previously overlooked as important bald eagle habitat because of lack of breeding adults are of critical importance to floating immatures that move great distances from one temporal food source to another.

As eagles aged, the tendency was to leave the GYE later in fall and return earlier in spring. Juveniles almost all left the GYE in mid September, returning in mid April to early May, as reflected by annual early and late detection times. Two year olds and older tended to leave in mid to late October, returning from mid to late march. Some eagles, notably the 2 fledged from the Third Creek nest in successive years, may have remained in the GYE as late as late mid January, leaving for only 1 month. Decreasing time away from the GYE was probably facilitated by increasing knowledge of routes and terrain as eagles grew older.

Data on movements during the second fall migration post-fledging are more sparse. However, initial directions of eagles leaving the GYE appeared more directly south. Implications of those direction changes are unknown but may have been influenced by increasing knowledge of geography and locations of seasonal food resources. The juvenile eagle followed west on its first migration did not visit the Great Salt Lake area but band encounters suggest that many older birds visit the area on both vernal and autumnal migration. Waterfowl are abundant an dispersed throughout the region and eagles are probably more likely to encounter concentrations as age increases.

As radio-tagged eagles aged, basic movement patterns remained but variability in both extent and frequency of long range movements increased. Movements of older immatures suggest increased wandering outside of the GYE in summer, especially north into Montana. In fact, an adult bald eagle that was a member of a productive pair on the Madison River in southwestern Montana from 1989 through 1992 had been banded as a nestling in the GYE (colorband sighting). A new breeding area initiated on the Missouri River, Montana, in 1991 was occupied by an adult bald eagle produced in the eastern Idaho portion of the GYE. Clearly, the highly productive GYE population has provided recruits to expanding populations outside of the GYE.

Whether near-adult and non-nesting adult bald eagles produced in GYE and summering there or near there leave in winter is unknown. Adult bald eagles nesting along free-flowing sections of the Snake River in Wyoming do not. All eagles associated with nests on the river were resident year round with at most only short periods away from the nest site, usually in autumn. Only the Third Creek pair left their primary breeding range in winter, most definitely in response to unavailable food resources associated with ice-covered Jackson Lake. Indications were that the resident pair did not migrate in the traditional sense but moved to the abundant food resources associated with elk winter ranges.

Although no data on seasonal movements of adult bald eagles in YNP exist, movements of the Third Creek pair may provide clues. Yellowstone Lake is essentially ice covered until late May, and adults associated with lake territories probably leave their primary breeding range in winter. Populations of wintering bald eagles along the Yellowstone River in Montana vary considerably, but numbers always account for the number of adults nesting in YNP.

Habitat Selection and Use

Nest Site Selection

Nest site locations of bald eagles in the GYE appear to be selected in order to provide maximum foraging opportunity at minimum distance from the nest. Site selection is further modified by structural constraints, i.e. suitability of available substrates for nesting, and further by human activity levels, probably in that order. Swenson et al. (1986) discussed type of nesting substrate available, and observations during this study indicate availability of nesting substrate was not limiting. However, in the SU of Wyoming, narrow leaf cottonwood was most commonly used species (Swenson et al. op. cit.; this study). Distribution and effects of water diversion structures (dikes, culverts, etc.), livestock grazing and highly manipulated flow regimes on the Snake River in concert with periodic drought conditions may be severely reducing distribution and availability of cottonwoods. Lack of periodic flooding in the Snake River flood plain favor late seral species, and little regeneration of cottonwoods was apparent, especially in SP. Throughout the SW, bald eagles appeared to select cottonwoods for nesting disproportionately to availability.

Characteristics of both the nest tree and nest in the tree were consistent with bald eagle nest sites in Montana (Jensen 1988). Nest trees were usually in dominant or co-dominant trees in more open stands. Sites were generally close to and in direct line of site of water near edges or openings in the stand (often the Snake River or Jackson Lake).

A consistent theme of bald eagle nest site selection along the Snake River in the SW was placement of nests in areas of high river diversity with less habitat removed by human activity, further supporting the concept of placement as close to food resources as possible. Although statistical significance may have been lacking in all cases, relatively high P values suggest biological significance in selection of nest sites in areas of close proximity to highly diverse portions of the Snake River as opposed to portions of low diversity. Additionally, if nest sites were not located in RMSs with highest RDI, they were located adjacent to and immediately accessible from the nest, i.e. within 100 m of the boundary of the RMS. These cases did not accurately reflect biological situation and were an artifact of sampling design.

A similar trend was evident with CEM. RMSs with eagle nests tended to be those with less total habitat removed by human activity. Several nest sites in the SU of Wyoming were obviously chosen to avoid proximity to human activity as much as possible yet retain proximity to high quality habitat. Sheep Gulch nest site was only about 210 m from one of the most heavily used boat pullouts on the Snake River. However, the nest was *downstream* of the pullout and very few boats continued downstream beyond the pullout. The nest also was visually insulated from the pullout. In this instance, CEM did not accurately reflect actual conditions to which Sheep Gulch eagles in the nest were exposed. All other active nests used in LSR during the study were located on the opposite shore from Highway 285 and the majority of human activity. In earlier (and later years), both Dog Creek and Cabin Creek pairs did fledge young from nests on the highway side of the river but in all instances nests were insulated from human activity by distance and steep slope (Dog Creek) or vegetative barriers supported by administrative closures (Cabin Creek). Ostensibly located in a marginal site, the Hoback nest site may actually have been in the best possible position to maintain close proximity to the Snake River but retain relative security from human incursion. The site was protected from most human incursion within 300 m by formidable barriers; the Snake River and precipitous embankments on both sides. Pedestrian or equestrian traffic could only originate from bridges at least 1 km to the north and south of the nest. Such traffic would be obvious to eagles long before the nest site was violated, thereby minimizing the disruptive effects. In SP, nest sites were similarly located. Sites were as far from housing developments as possible when located on the same shore or, positioned on the opposite shore. Clearly, human activity levels affected nest site placement in SU of Wyoming.

Discriminate analysis of distances of bald eagle nest sites and selected nonused sites to specific components of the habitat in the LSR further support the concept that more productive pairs nest closer to river areas of higher diversity and food availability. More productive nest sites had higher weights in analysis, thus were more represented, as were distances to habitat components associated with these sites. Analysis showed proximity to riffles was important to nest site selection (Table 37). Riffles are areas of high diversity and concentrate fishes, both spawning and feeding. Invertebrate hatches occur in riffles in spring, presumably concentrating fishes attracted there, thus drawing eagles too. Swenson et al. (1986) suggested proximity of early spring food sources were important in nest site selection for bald eagles in the GYE.

Jensen (1988) found bald eagle nest sites in Montana were in close proximity to open areas. In the LSR, a similar trend was evident. Productive bald eagle nests were closer to meadows (Table 37, MED) than nonused sites. Jensen (1988) speculated proximity of open areas was related to survival of recently fledged progeny. Nest sites in thick timber would inhibit detection of fledglings by parental adults for feeding and protection from terrestrial predators such as coyotes and dogs. In fact, a recently fledged, flightless bald eagle on the ground in heavy timber in Glacier National Park MT was not fed by adults until researchers moved it to the nearest shoreline (R. Yates and B.R. McClelland pers. comms.). Recently fledged young in LSR sometimes spent significant time immediately post-fledging on the ground before powers of flight were sufficiently developed. One fledgling bald eagle was found dead below the Butler Creek nest site, apparently killed and partially consumed by dogs. Remige development indicated it was only 10-11 weeks old and recently fledged. Vegetation below the nest was thick, possibly inhibiting defense of the eaglet by parental adults by impeding aggressive, low level aerial attack directed at predators.

More productive eagles tended to perch closer to the nest than less productive eagles, especially females (Table 49). Females would be expected to reflect the relationship to a greater degree due to stronger nest site affinity, especially during the breeding season. That males tended to reflect the relationship at all may be more significant biologically than statistical significance indicates. Males are responsible for most of prey for the pair, especially during the breeding season (Stahlmaster 1986) and would conserve energy if more requisites were available closer to the nest. Certainly, eagles expending more energy ranging farther and more frequently away from the nest site would have less to invest in breeding and result in fewer young produced. Analysis also hinted that observations of unmarked pairs may have been mostly of females because when pair curve characteristics were lumped with males, R^2 and P values declined. Although the same held true for the relationship when pairs were lumped with females, significance was maintained. Perch to nest distance relationships further support the concept that eagles tend to select nest sites as close to habitat that fulfills requirements as possible. Proximity to good habitat is reflected in enhanced productivity.

Selection and Use of Habitat within the Home Range

Habitat use was a function of habitat quality (RDI), quantity (CEM) and proximity of habitat components from most recently active nest. RDI appeared to be a good indicator of lotic habitat, however eagles used habitats off river, some times to a high degree, especially seasonally (n.b. Schwabacher male's use of Cottonwood Creek, Jenny, Leigh, and Taggart Lakes). Real influence of river habitats on nest site selection and overall habitat use is of course, unknown. However quality of riparian habitats appears of prime importance for selection of nest sites and determining productivity of bald eagles associated with the Snake River.

Movements, perch selection, flushing distances and circumstances of increased tolerance of human activity suggested perches were selected for proximity to the nest site and food resources but modified to avoid human activity when possible, if not spatially then temporally. Both perches and preforaging perches of eagles in the LSR were at least 200 m farther from houses than nonused locations indicating a strong avoidance of human activity centers. Aside from temporal responses of the Elbow pair, eagles in the LSR obviously avoided proximity to U.S. Highway 26/285 and its relatively constant human activity. Most perches used by eagles in the LSR were on the side of the river opposite the highway and concentrated areas of human use, an obvious example of spatial avoidance. Choice of perches closer to private land further indicated a selection of areas with minimal human activity. Perch sites were then influenced by habitat components related to proximity and availability of food, i.e. wetlands and deep runs. Perch site selection also suggested that both eagles and recreationists chose similar areas. Perch site distances to campgrounds and boat launches were quite small, suggesting conditions on the river that facilitated placement of recreational areas also possessed attributes consistent with good foraging opportunities for eagles, i.e. wider, gently sloping flood plain, shallow depths, riffles and deep runs.

Flushing distance analysis showed eagles similarly avoided humans spatially. Considerable differences existed among mean flushing distances, depending on area. Flushing distance was greatest on the Snake River in ST and smallest in LSR. Most activity in LSR was predictable and concentrated in specific areas (i.e. campgrounds, pulloffs, highway) usually on just one shore. Few exceptions occurred and eagles obviously habituated (within limits). On the Snake River in ST, anglers and floaters often stopped randomly along the river on both shores, at unpredictable times, often assuming pedestrian status. Few events are more disturbing to bald eagles than pedestrians, especially when present outside predictable use areas. Greater flushing distance in ST probably reflected the unpredictable human use of the Snake River. A similar situation occurred in SP.

Relatively small flushing distance on Jackson Lake reflected type and distribution of recreational use. Most human activity was either associated with predictable use areas (Colter Bay, Signal Mountain Lodge, boat launches) or with power boats which seldom stopped near perches or on shore. Few pedestrians unassociated with commonly used areas were present on the lake shore. Expansive views from lake shore perches probably helped eagles evaluate movements of watercraft, most of which were nonthreatening.

Data indicate that although human activity precludes eagle use of some areas, eagle response (i.e. resumption of use) to removal of activity was rapid and even immediate in some cases (see Elbow and Cabin Creek male narrative in *Temporal and Spatial Avoidance of*

Human Activity). A temporal variable was generally not considered in calculation a CEM value. When timing of human use was incorporated in calculation of CEM seasonally and hourly and related to concurrent perch use for the Schwabacher male, R^2 of perch use to percent habitat remaining increased to significance. The Schwabacher male used RMSs with overall low CEM values (little habitat remaining) but mostly when humans were not present (actually all habitat remaining). Inclusion of a time variable in calculation of all CEM values would increase the value of the model and more accurately reflect true condition.

Eagles in the LSR appeared to compensate for excessive human activity on the river in summer by foraging in early morning and evening. Bimodal pattern of foraging activity was not inconsistent with typical avian foraging patterns but may represent de facto avoidance of human activity. Fortunately (for the eagles), the crush of human activity during the study period occurred directly between the modes of bald eagle foraging activity and apparently has not affected productivity or occupancy of nest sites. As human populations continue to grow, more recreation pressure will expand the peak of river use earlier and later in the day. Human activity on the river will infringe more and more into bald eagle foraging periods, removing habitat.

Home Range Diversity Indices suggested eagles expanded their home range to include a minimum amount of diversity. One possible result of increased mode widths of human activity may be eventual reduction of productivity and subsequent reduced occupancy of nest sites as more productive (or aggressive) pairs expand their home range and eliminate less productive (or subordinate) pairs whose site tenacity and access to recruits drops. It may also be possible that increasing tolerance and adaptation to human activity noted in some pairs may continue and offset increasing human encroachment on habitat. Time will tell.

HSI relationships revealed an interaction between RDI and CEM. Areas that received high or medium use by bald eagles on the river consistently contained more highly suitable habitat as reflected by relative HSI values. Conversely, areas that received little or no use by bald eagles were of low habitat suitability. Eagles appeared to have tolerated more habitat withdrawn by human activity if quality was high but also used habitat of low quality if little or none were withdrawn by human activity, although to a lesser extent. Data suggest a threshold of 33% perching habitat remaining was minimum tolerated in highest quality habitat, while RMSs with 80% and higher habitat remaining were used the most, somewhat independent of RDI. Habitat management directed to improving habitat diversity along the Snake River may partially offset the population depressive effects of more and more human use.

Amount and number of habitat components incorporated in bald eagle home ranges in the LSR (Table 39) indicated that eagles included minimum amounts of habitat. Data indicated the range which could tolerate the most reduction in size, the Cabin Creek range, in fact eventually did. The Elbow pair pioneered a breeding range directly between Sheep Gulch and Cabin Creek and although the absolute area was significantly truncated, habitat requisites were abundant enough to support 2 pair.

Highly significant logit regression of cumulative percent perch-to-nest and forage-to-nest distance curves (Table 38) indicated distance affected the extent of which habitats within the home range were utilized by nesting adult bald eagles, somewhat independently of HSI. Results indicated calculated or predicted curves are useful in comparing movement patterns among different eagles and showed amount of eagle use a portion of the home range received was partially related to distance from the active nest. Habitats at greater distance tended to be used less, regardless of quality.

An apparent exception was the Sheep Gulch male. Exploited habitats were about 4 km from the nest site and may indicate the marginal condition of the home range. The nest was situated in the portion of the home range which received the least possible intrusion by humans and was also visually insulated from most human activity. The site was apparently the only place in the entire home range which met those conditions but still was close to or within sight of the Snake River. Food resources however, were far removed from the nest site as shown by perch-to nest distances (Table 38).

Use areas of bald eagles were defined by perch use and may not be entirely indicative of overall use within the home range. Eagles were observed hunting in flight and certainly "used" river areas during flight not reflected by perch use. Kilometers of shoreline included in home ranges may add insight into overall use of the home range and be indicative of overall quantity and distribution of habitat within the home range. Length of shoreline in home ranges of bald eagles in LSR and SP was remarkably similar regardless of length of river included suggesting eagles were selecting for a minimal amount of shoreline in the home range. River nesting eagles in ST included over twice as much shoreline than eagles in LSR and SP, suggesting a relationship of shoreline *configuration*, modifying the effect of length. Eagles including mostly straight sections of river in the home range tended to include more shoreline than eagles with home ranges containing sinuous and braided portions of river (c.f. Hoback, Schwabacher, Oxbow pair to Cabin Creek, Dog Creek, Butler Creek). More convoluted shorelines most likely include more diversity of water depths, flows, temperatures, cover types, etc. providing more diverse aquatic habitats resulting in higher fish populations than straight shorelines.

Although statistical significance was lacking, correlation relationship directions (not magnitude) in area use by season as related to area diversity may suggest biological significance for the Third Creek bald eagle pair. Use area weights were inversely correlated with mean LDI of respective use areas from W through LN seasons for both genders. Adult eagles may have been more quickly successful at prey capture in high diversity areas, consequently spending less time there with fewer visits, resulting in lower weights. Prey availability may have been higher in these areas thus less time was required for detection and capture. Once prey populations were depressed below a level of availability that made continued exploitation inefficient, eagle use shifted to low diversity areas of relatively and temporarily higher prey availability, permitting recovery of primary use areas with high LDI. High weight use areas during W, EN and LN seasons may indicate areas where more time was required to detect and obtain prey. These areas may have been valuable "buffer areas", use of which permitted recovery of more diverse areas. Of course parameters chosen to calculate LDI, measurement thereof and changing seasonal floral and faunal relationships in the lake may have not been representative of true diversity, prey availability or human activity throughout the year, or at all. Calculation of LDI failed to incorporate the effect of lower water levels concentrating fish in both the main lake and sequestered pools. It also did not consider the tendency of exposed mudflats and islands to attract nesting and molting waterfowl. Both conditions may have improved availability of prey. Consequently, areas of high use during low and medium water levels may be more representative of high quality lake habitat and prey availability than LDI.

Correlation of weight with mean LDI of respective use areas shifted from negative to positive from LN to PF season, through F and W for the Third Creek male. Third Creek female shed her transmitter too early in the PF season to detect such shifts. Positive correlations of weight with LDI during these seasons may be a function of parent eagles tutoring fledglings, assisting in development of search image for areas of high diversity/prey availability. Fledglings were noted to follow adults on foraging expeditions soon after fledging. Positive correlations may have also indicated changing prey distribution, effects of increased water associated recreational use, or both.

Water level may have affected productivity of the Third Creek pair and their use of the lake. When the Third Creek site was discovered, water level was medium and the eagles produced 2 young. In 1988, water level was also medium and the pair produced 1 young. In 1989 when water level had returned to high, the pair failed to produce. At low and medium levels, mean LDI was low but somewhat uniformly distributed around the lake. Eagle use areas were likewise distributed rather evenly throughout the home range. As water level rose, mean LDI increased but deviation of LDI increased also and areas of higher diversity were few and more widely distributed. A lag time of refamiliarization with the habitat may have been responsible for lack of productivity during the first year of high water. In 1990, with high water, the pair again produced.

Interestingly, when the Third Creek pair was most productive, human activity (Jackson Lake Dam reconstruction) in proximity to the active nest and high use areas was greatest. When reconstruction work ceased, the pair failed. This implies that high quality habitat may partially offset negative affects of human activity, within limits.

Implications of Environmental Contaminants

Contamination of the prey base with DDT and its metabolite DDE and resultant egg shell thinning has been notorious in population declines of bald eagles and peregrine falcons (*Falco peregrinus*) (Broley 1957, Carson 1962, Hickey 1968, Wiemeyer et al. 1984). However, recent evidence indicates despite wide spread shell thinning in western peregrine falcon eggs, productivity was not always affected. Only when thinning exceeded 17% was peregrine productivity depressed (Enderson and Craig 1991). A similar threshold phenomenon may occur for bald eagles. GYE bald eagles and eggs showed generally moderate amounts of DDE contamination and shell thinning (Tables 49 & 50) but overall productivity was good to excellent. In the absence of other factors depressing reproduction, low to moderate levels of organochlorine contamination may be of no consequence. However, productivity of 2 breeding areas was considerably lower than predicted by percent shell thinning alone. Effects of DDE/DDT and other organochlorine contamination below threshold may have exacerbated productivity problems in breeding areas where fecundity was already depressed by severe weather. Severe weather and below threshold contamination may exert a synergistic, negative affect on productivity as reflected in long term reproductive performance of bald eagles associated with Oxbow and Wilcox Point breeding areas.

Extent of organochlorine contamination is most likely a function of breeding area location and associated prey. DDT has not been used in the GYE since 1964 (Mussehl and Findley 1967) and despite persistence of the chemical, recent residues in eagles and their eggs have probably been imported in the migratory prey base. Waterfowl and piscivorous birds accumulate and concentrate organochlorine compounds (Kieth 1966, Dindal and Peterle 1968). Contaminant loads of eagles more frequently exploiting such a prey base would be higher than those that did not. Egg shell fragments from the productive Schwabacher nest in 1988 were normal or supernormal while egg shells of eagles associated with breeding areas on or adjacent to Jackson Lake (collected in 1983) were moderately to significantly thinned. Schwabacher home range and use areas included mostly Snake River where few waterfowl breed, winter or use as migratory staging areas. Large numbers of waterfowl congregate on Jackson Lake during biannual migrations and many summer or breed there. Conditions of the Oxbow of the Snake River mimic a lentic system and waterfowl use is intense, especially in spring and autumn. Adults associated with the Schwabacher breeding area consume fewer waterfowl than adults breeding on Jackson Lake or the Oxbow, just by virtue of opportunity.

The only nestling that showed residues of DDE in blood was produced in the Centennial Valley of southwestern Montana. Red Rock Lakes NWR is also in the Centennial

Valley and supports multitudes of breeding and migratory waterfowl. Populations are more abundant and dense than at any time on Jackson Lake (C. Mitchell, Asst. Ref. Mgr. pers.comm.). Waterfowl remains were found during nestling banding in 1991 and adults were observed hunting ducks on lakes. Food base, food habits and blood residue further indicates DDE contamination in bald eagles was linked to availability of waterfowl.

Moderate organochlorine contamination was evident in nestlings produced on Hebgen Lake in southwestern Montana (Table 50). Hebgen Lake is also an important seasonal use area for large numbers of migrant and breeding waterfowl that are preyed on heavily by resident and migrant eagles. Annual productivity of eagles breeding on Hebgen Lake has shown extreme variability but overall has been low. Again, vernal weather is severe and may interact with contaminants depressing productivity. Several immature bald eagles radio-tagged as nestlings visited the Centennial Valley and Hebgen Lake at times when waterfowl were abundant, some over several years. Nonbreeding bald eagles in the GYE may be accumulating oganochlorine compounds during their peregrinations throughout the GYE by feeding seasonally on contaminated food base.

Samples analyzed for organochlorine residues were gathered serendipitously throughout the study. Analyses differed significantly and samples were collected over nearly a decade. Comparisons and extrapolations are tenuous at best. Perceived trends may be attributable to gradual leaching of organochlorines from the ecosystem over time and/or nothing more than poor sampling, rather than real differences in contamination. More systematic sampling of prey and resident adult bald eagles is needed to interpret contaminant loads, trends and implications with confidence.

ChE analysis indicated at least one nestling bald eagle in the Centennial Valley of southwestern Montana possibly affected by organophosphate or carbamate pesticide. Ground squirrel and coyote control by private interests is intensive in the Centennial Valley and in fact, most private lands in and adjacent to the GYE. Organophosphate and carbamate insecticides are often used illegally and inappropriately towards those ends (Henny et al. 1987). Five bald eagles radio-tagged as nestlings visited the Centennial Valley, some over several years. Bald eagles produced throughout the GYE may be at risk from organophosphate or carbamate pesticides while occupying private rangelands in the GYE and vicinity.

Lead induced mortality has been documented clinically and in the wild for bald eagles (Pattee et al. 1981, Pattee and Hennes 1983) and in fact, several eagles in or from the GYE were known to have been killed by Pb poisoning. Apparently, Pb contamination was a problem during the study. Sublethal effects are less obvious and may include anemia, reduced capacity to combat infections (Hoffman et al. 1981, Redig et al. 1983) and neurological damage (Heinz 1988). However, the relationship of blood Pb levels, tissue levels, and severity of Pb poisoning is unclear. Detectable blood Pb levels in eagles may indicate chronic, low level exposure or recent acute toxicosis either increasing or decreasing but trends obviously cannot be detected with a single sample. The USFWS has established ≥ 0.5 ppm Pb in blood of eagles as indicative of toxic but sublethal exposure (Redig 1985). A level of 0.2 ppm was considered elevated above background levels in waterfowl (Sanderson and Bellrose 1986). Deiter (1979) found symptoms of Pb toxicity appearing at 0.2 ppm in ducks. Redig et al. (1983) considered blood Pb levels of 0.2-1.0 ppm indicative of toxic, chronic, sublethal exposure.

Pb levels in GYE bald eagles not manifesting obvious problems are difficult to interpret. Two eaglets resident in the Third Creek nest during 1987 had no detectable and 0.2 ppm Pb levels in blood. The high level may have been residual of a single contaminated food item, however tissue bound Pb in prey species is not suspected to play a role in Pb toxicosis in raptors (Pattee and Hennes 1983, Custer et al. 1984). Possibly, the eaglet had ingested waterfowl containing Pb shot (unlikely in June or July) or a fish containing Pb sinkers.

A smaller proportion of nestling bald eagles in the GYE had detectable Pb concentrations than adults but those that did had relatively high concentrations (0.25 ppm), especially when considering their age. Some nestling eagles in ST, SI and CI consequently may be at risk due to high concentrations of neurologically detrimental Pb.

Curiously, Pb concentrations in blood of resident, nonnestling bald eagles were low, detected levels considerably lower than nestlings. Of 11[1] adult bald eagles sampled in the study area, 5 exhibited detectable concentrations of Pb in blood. Blood Pb levels in the Schwabacher male eagle changed dramatically between captures (Table 54). Interestingly, the highest Pb concentration was detected during winter, a time when Pb crippled or contaminated waterfowl would most likely have been encountered. Sixty-four percent of eagles with undetectable concentrations of Pb were sampled in summer, supporting the theory that Pb was imported into the ecosystem by contaminated waterfowl, mostly in autumn and winter.

Pb concentrations of migrant bald eagles were very high. High concentrations were most likely a function of feeding on waterfowl crippled or killed by Pb shot encountered during autumnal migration farther north. Redig (Raptor Ctr., Univ. Minn. pers. comm.) felt eagles with blood Pb concentrations ≥ 0.8 ppm (wet) should be quite debilitated or at least appear quite sick. None of the free flying, migrant bald eagles captured in the GYE appeared so. Calcium mitigates effects of Pb (Heinz 1988) and high calcium diet of bald eagles may mask any detrimental effects of Pb.

Blood of resident bald eagles tested in the study area contained a mean of 0.49 ppm Hg but nonnestling eagles sampled contained $\bar{x} = 1.6$ ppm. Concentration level increased with age and illustrates the cumulative nature of the contaminant. Blood Hg in resident adult and immature eagles was high (Table 51) indicating resident eagles fed on a moderately contaminated food supply (Heinz 1980). Mean Hg level in the study area is higher than that reported by Frenzel and Anthony (1989) and their samples were obtained in an area widely regarded as heavily contaminated but supports mostly migrant eagles.

Origin of Hg in the watersheds of the GYE is unknown but often source is related to leaching from hard rock mine tailings treated with the "Washoe Process" (Martin 1992). Active and inactive mines were present on the upper reaches of the Gros Ventre and Buffalo Fork Rivers. Another possible source of contamination in the Snake River watershed may be from natural thermal effluents in YNP. Once in aquatic ecosystems, Hg is bioaccumulated in fish as methyl Hg through micro-organisms (Colwell et al. 1975) to invertebrates (Hildebrand et al. 1980) or by water through gill surfaces (Phillips and Buhler 1980). Tissue Hg in some fishes increases exponentially with size (Phillips et al. 1987).

Dietary Hg affects raptorial species neurologically (Fimreite and Karstad 1971) and reproductively (Wiemeyer et al. 1984). Neurological effects appear to be manifested in a threshold effect (Fimreite and Karstad 1971, Heinz 1980) and result in overall weakness and wasting. Hg residues have varying effects on hatching rates, dependent on species (Vermeer et al. 1973). Contrary to findings of Frenzel (1985) in Oregon, adult female eagles had slightly higher Hg blood levels than adult male eagles (2.7:2.3 ppm), possibly reflecting the propensity of larger females taking larger, more contaminated fish. However, bald eagles may not readily deposit Hg in egg tissue as other avian species (Heinz 1980). Regardless, GYE bald eagle productivity has been increasing since 1978 (Fig. 10). Future study should monitor the level of Hg in both nonadult and adult bald eagles in the GYE.

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1. Includes one eagle captured and sampled twice

Mean Se concentrations in blood of bald eagles in the study area were relatively high (1.56 ppm overall, 3.21 ppm for residents), detected in 100% of eagles sampled and generally related to age (Tables 51 & 52). Toxic blood levels have not been established for raptors, but toxicity in bovines was indicated at 0.5 ppm (G. Heinz, Patuxent Wildl. Res. Ctr., pers. comm.). The applicability of this toxic level to birds is tenuous. Se induced mortality has been documented in waterfowl (Ohlendorf et al. 1988) but effects are primarily teratogenic or manifested in reduced natality or productivity (Hoffman et al. 1988). These effects have not been documented in bald eagles. In the GYE, Se may mitigate or prevent deleterious effects of Hg and both may interact synergistically, reducing toxicity and permitting higher tolerance concentrations of each (G. Heinz pers. comm.), much as calcium mitigates toxicity of Pb. Adult bald eagles had high levels of Hg (1.4-4.0 ppm). However, whether uptake of Se was related to Hg concentrations, or vice versa, or if blood levels of each was unrelated is not known. More research is needed on the extent of environmental contamination with Se and effects on bald eagles.

Effects of environmental contamination in GYE eagles are unknown. Although organochlorines may interact with weather to depress fecundity, productivity of the population was good and juvenile survival appeared excellent. However, juvenile and immature bald eagles produced in the GYE move west towards the coast in autumn to winter. Coastal wintering grounds are heavily contaminated (Frenzel and Anthony 1989) and conditions outside of the GYE may eventually affect survival and fecundity of potential recruits to the GYE population. Adult turnover appeared high also, especially in males. Reproductive life and survival of adult bald eagles in the GYE may be curtailed due to contamination, a phenomenon masked by positive effects of easily available abundant food base promoting good short term reproduction. If human activity continues to remove and contaminate habitat, contaminants may contribute to an overall synergistic effect, depressing the population at a faster rate than habitat loss alone.

Applicability of Results to Management Guidelines

Interim management guidelines have been used to maintain desired habitat characteristics and human activity levels at bald eagle nest sites in the GYE (GYEBWT1983). Management guidelines recommend 3 zones with decreasing levels of management intensity. Interim management zones are defined as follows:

Zone I - Area within 400 m of occupied and alternate nests.

Zone II - Area within 800 m of occupied and alternate nests.

Zone III - Areas within a 4 km radius from the center of Zone II that includes aquatic and wetland habitat.

Summary of management recommendations for each zone are presented in Table 57. In this section, justifications for zones (400 m, 800 m and 4 km) are reviewed and compared with relevant findings from this study.

A zone limit of 400 m was selected primarily because defense against human intrusion by GYE nesting eagles has been observed up to 400 m. Other studies present findings which support the 400 m distance (Fraser et al. 1985, Lehman et al. 1980, McGarigal et al. 1991). Flushing distance in response to human activity in this study indicated that perched bald eagles were extremely sensitive to human activity within 200 m. However, a significant portion

(29%) of eagles flushed in response to human activity within the 200-800 m range. Analysis of distance between preforaging perches and foraging locations indicated that bald eagles were especially cognizant of events within 200 m; while their zone of attention clearly extended to 400 m (Table 28).

Zone II includes the area within a 800 m radius of the active nest and all known alternate nests. While management recommendations for Zone I focuses on preventing human disturbance at an occupied nest, recommendations for Zone II focuses on protection, management and maintenance of important habitat components for nesting eagles. The maintenance of adequate nesting structures and foraging habitat in this zone is essential. In addition, recommendations are intended to prevent levels of human activity in areas that would preclude use of most foraging habitat within the home range. References further supporting Zone II radius distance include: Broley (1947), Mathison (1974), Gerrard et al. (1980), and Swenson et al. (1986).

Data presented in this study indicate nests are located most proximate to important (highly used) foraging habitat within the home range of a pair, further emphasizing the importance of Zone II boundaries for protecting foraging habitat. Home range use observed in the study was compared to Zone II of each nesting pair (Table 58). Results presented in Table 58 indicate that significant portions of high and medium use areas were included in Zone II for all breeding areas except perhaps Sheep Gulch, Hoback and Third Creek.

A small number of observations of 5 pairs in the study area between 1978 and 1981 suggested that important foraging habitat could be located anywhere within 4 km of nests. However, only foraging habitat and a 400 m buffer was included in Zone III. This study documented home ranges that were considerably larger. However, mean lengths of Snake River included in home ranges were 12.6 km(LSR), 5.1 km (SP) and 9.32 km (ST), which roughly compares with 8 km length of river recommended for inclusion in Zone III. Perch to nest and forage to nest distances were compared with the 4 km radius of Zone III. At the 50% level, only 2 of 12 eagles (Third Creek and Sheep Gulch males) exceeded 4km (Tables 30 & 38).

Table 59 displays percentage of entire area delineated by high and medium use areas included in Zone III of eagles monitored in this study. Nearly all high use areas delineated were included in Zone III. As with other analyses, the Sheep Gulch male was the exception with only 11.3% of the high use included in Zone III.

Interim management guidelines (GYEBWT 1983) appear applicable to 7 of 10 bald eagle breeding areas intensively studied. Breeding areas where guidelines are noticeably lacking include 2 along the Snake River and 1 associated with Jackson Lake. The 2 on the Snake River were heavily impacted by human activity and included significant portions of low quality habitat. Guidelines would be insufficient for adequate protection of important habitat components within the home ranges. Applicability of guidelines to Jackson Lake breeding areas is affected by large size of the Lake and distribution of potential use areas. Management of all 10 breeding areas could be improved by focusing on bald eagle high use areas and areas with high quality habitat. In breeding areas not intensively studied to delineate high and medium use areas, management could be improved by using RDI, CEM and HSI ratings to delineate Zone II and apply management strategies.

CONCLUSIONS

The GYE bald eagle population has increased dramatically since 1978. The Wyoming portion of the SU more than doubled between 1978 and 1991. Enforcement of legislation to prevent eagle mortality and banning the use of strychnine and DDT probably contributed to the increase (Swenson et al. 1986). Population trends, nesting densities, production, survival and recruitment to breeding pairs all indicate a secure population.

Vacant habitat for nesting bald eagles was obviously present in the 1970's and 80's but may not be present for further population increase. In fact, increasing human populations and recreational use indicate bald eagle habitat will decrease in both quality and quantity in the future.

This study focused on one segment of the GYE population. Data clearly indicate that eagles nesting along the Snake River provided recruits to the both the SU and other segments of the population, some not able to maintain stability with internal production (e.g. the YU). The importance of maintaining the health and production of bald eagles nesting along the Snake River in Idaho and Wyoming cannot be overstated. It is essential to the maintenance of bald eagles in the entire GYE. Additionally, young eagles produced in the SU depend on habitats in western coastal states and throughout the GYE for survival prior to being recruited into breeding populations. Effective management will require an extensive regional approach in addition to attention to ecosystem, population unit and breeding area specific objectives to ensure future health and maintenance of the GYE bald eagle population.

Three conclusions were consistently apparent throughout most aspects of this study: (1) bald eagles adjust use patterns in response to changing habitat conditions to maximize foraging efficiency, (2) bald eagles consistently utilize their habitats in a geographic and temporal manner that minimizes human encounters and, (3) given enough time and space, bald eagles can adapt and tolerate human activity and presence *within site specific limits and conditions*, as long they occur within definable, predictable, inviolate boundaries and intensities. Adjustment to habitat conditions and avoidance or tolerance of human activity, were reflected in home range size, nest site selection, primary use areas within home ranges, activity patterns and seasonal and daily movements.

This study quantified, qualified and monitored habitat and effects of human activity and related to bald eagle productivity, movements and habitat use. Results permit determination of realistic management objectives and guidelines for bald eagles nesting along the Snake River. Due to the adaptability of bald eagles, loss of specific nest site(s) or lower production per pair should not be used as a reliable indicator to habitat deterioration or increasing human impacts in the short term. Rather, research findings suggest that total number of nesting pairs or total young produced in a stretch of the river (e.g. LSR, SP, ST) during a 5-10 year period will be more indicative of changes in habitat and/or human activity conditions. Unfortunately these indices are "after the fact." Dynamics of the Snake River and persistent and increasing human use patterns suggest that attempts to improve Snake River habitat that has deteriorated or to alter established human activity patterns will be extremely difficult and costly, if not impossible. A pro-active management approach is needed to prevent population declines.

MANAGEMENT PROBLEMS AND RECOMMENDATIONS

Management problems identified within the SU of Wyoming (italicized, by number) and recommendations to address problems (indicated by letters) are presented below. Some recommendations refer to specific research activity.

1. *Population objectives in the GYE and Wyoming have not been updated since 1986*[1] *and may not be appropriate.*

    a) Encourage the GYEBWT to review objectives.

    b) Recommend for the SU of Wyoming that at least 3 nesting pairs of bald eagles are maintained in LSR, 5 pairs in SP, and 8 pairs in ST.

    c) Attain public involvement and consensus of objectives.

2. *Bald eagle use may be precluded from important habitats and population declines may occur, unless there is adequate management of human activity, resource use and developments.*

    a) Complete management plans specifically for LSR, SP and ST.

    b) Delineate primary management parcels (PMP) that have high RDI ratings and/or received high or medium eagle use during this study (Appendix Figs. 1-45). Relevant RMS are: 8, 9, 12, 14-21, 26, 30-40, 47, 48, 51-54, 57, 59, 60, 62, 68, 69, 71, 74, 78-80 (Figs. 18-20).

    c) Develop RDI, CEM and HSI objectives and management strategies for each PMP. Implement and monitor results.

    d) Until 2c is completed, Zone II guidelines (GYEBWT 1983) should be applied to all PMP.

    e) Use high and medium perch areas (Appendix, Fig. 18-45) associated with bald eagles using lakes to delineate Zone II. Apply Zone II management guidelines (GYEBWT 1983).

3. *Development of private lands could make it impossible to maintain population objectives and PMP objectives.*

    a) Jackson Hole Land Trust, Teton County Planning Commission, and private landowners have facilitated greatly maintenance of bald eagle habitat on private lands. Resource managers should continue to assist these groups whenever possible.

    b) The most important habitat, in terms of RDI ratings and total eagle production (1978-91) is vulnerable. Efforts to secure these habitats by purchase, easement or cooperative agreements with landowners need to be intensified. These habitats are included in portions of RMS 17-21 and 35-37 (Figs. 18-19).

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[1] *Pacific states bald eagle recover plan, USFWS (1986).*

c) If private lands on the east side of the Snake River in RMS 17-21 (Fig. 18) cannot be secured by 1995, the USFS should greatly reduce public use (i.e. campgrounds, boat landing, etc.) on the west side of the Snake River.

4. *Adequate data on number of bank users and floaters along the Snake River are not being maintained by resource management agencies.* Lack of data will preclude future calculation of CEM ratings, monitoring of use trends, evaluation of management decisions and adequate management of recreational use.

a) USFS, BLM and NPS should conduct periodic workshops to compile the most recent knowledge to adequately quantify recreational use as it relates to bald eagles and other public concerns.

b) Workshops (4a) should recommend an interagency program to quantify and monitor recreational use on the Snake River in Wyoming and Idaho.

c) A recreational use inventory program should be funded and implemented for the Snake River by 1998 and should be well coordinated with all involved agencies.

5. *Recreational use (especially noncommercial floating) is increasing and is likely to reach levels that will preclude bald eagle use of significant portions of the Snake River.* Attempts to limit recreational use will be controversial, need to be well justified and could shift increased human use or problems to other areas.

a) Workshops (4a) also should be designed to: compile most recent knowledge on recreational use and management; establish objectives for all portions of the Snake River; and recommend threshold levels with interim management actions that should then be implemented.

b) Recreational management plans for the Snake River in Idaho and Wyoming should be developed by NPS, USFWS, BLM, USFWS and respective state fish and wildlife agencies. Management plans should include public involvement and review.

c) Ongoing efforts to prevent conflicts with recreational use and bald eagle requirements should continue in the management area until strategy 5b has been implemented.

6. *Heavy sediments loads caused largely by the inadequate design of levees, will continue to cause degradation and loss of bald eagle habitat, especially in SP and LSR.*

a) Continue work with the Army Corps of Engineers (ACE) WGFD and USFWS to initiate or fund studies to: (1) quantify and characterize the existing problem; (2) identify specific areas where degradation or loss of habitat may occur in the future; and, (3) recommend and implement projects to address site specific problems (short term) and long term problems within the Snake River Ecosystem, caused by levee systems.

b) Continue to identify and implement habitat improvement projects on feeder streams and wetlands adjacent to portions of the Snake River with levees.

7. *Data indicate that bald eagles are still accumulating organochlorines and relatively high levels of heavy metals.* They also may be at risk from organophosphate or carbamate pesticides. Contaminants could affect production and survival and preclude maintenance of objectives.

a) Continue to monitor production and population trends in the GYE.

b) Encourage additional research and compile data from other studies to determine the source of heavy metals and other contaminants and possible effects on GYE bald eagle populations.

c) Check blood concentrations of heavy metals, organochlorine residues and cholinesterase from a sample of adults and young every 5 years and examine trends.

d) If eagle population or contaminant metal data indicate a problem, initiate planning and programs to address it.

8. *Site specific information was obtained that will be useful in management of 2 nesting pairs associated with Jackson Lake.* The limited sample size precluded development of guidelines applicable to lake nesting eagles in general.

a) Develop a CEM rating similar to the approach used by Montopoli and Anderson (1991) for lentic systems.

b) Based on methods of this study, develop LDI ratings for lake habitat further.

c) Study additional lake nesting eagles in YU and CU intensively (radio-telemetry, colorbanding) to determine if LDI and CEM ratings are useful in explaining or predicting eagle use of lake habitat.

d) Encourage appropriate analysis and review of ongoing studies of lake nesting eagles in Idaho.

9. *Although mathematical formulas for RDI, CEM and HSI indices appear to increase understanding of bald eagle habitat use, inherent limitations reduced applicability.* Data were collected on a relatively small number of eagles (N=8) specific to the Snake River, Wyoming. CEM rating generally did not reflect geographic and temporal fluctuations of human use on the river. Only locations of the Schwabacher male were analyzed with coincident time/season specific CEM. Results were more representative of the true condition and punctuated need for coincident eagle location/CEM calculation in analysis. CEM ratings in other breeding areas were established by RMS for summer and relevancy between eagle locations and temporally and/or spatially respective CEM was reduced. Such analysis may be somewhat artificial, diluting biological reality in some cases. These limitations may also limit management effectiveness.

a) Work with existing data to improve indices of nests studied.

b) Conduct similar analysis on other nests currently being studied in the GYE.

c) Expand analysis to include nesting pairs associated with other river systems.

10. *Few eagles have been banded in some portions of the GYE, especially the YU.* Additional wintering and subadult habitat may be in need of management that currently is not receiving attention.

- a) Continue banding with emphasis on YU, CM and GTNP.
- b) Continue review and analysis of band encounters.

11. *The GYE management plan has not been updated since written and new data provide new perspective on bald eagle ecology and problems that may modify objectives and guidelines.*

- a) Identify and compile new problems, conditions and tenets of bald eagle ecology in the GYE from existing literature and studies in progress.
- b) Rewrite the GYE bald eagle management plan.

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TABLES

Table 1. Colorbanding scheme for bald eagles resident or native in the Greater Yellowstone Ecosystem. A BLUE color scheme for eagles captured between November and March whose residency status was uncertain, replaced GREEN below.

Population Unit	Band Color (Position)	Leg
Snake Wyoming	White (over) Green	Right
Snake Teton	Green with White Mid-line Stripe	Right
Snake Idaho	White (over Green)	Left
Continental Montana	Green (over) White	Right
Continental Idaho	Green (over) White	Left
Yellowstone	Green with White Mid-line Stripe	Left

Table 2. Organochlorine and polychlorobiphenyl compounds tested in blood of bald eagles in the Greater Yellowstone Ecosystem.

Compound	Detection Limit (ppb)	Compound	Detection Limit(ppb)
Mirex	19	Aldrin	3
Methoxchlor	35	Heptachlor	2
p,p DDT	13	Lindane	3
p,p DDD	9	δ-BHC[1]	2
p,p DDE	3	ß-BHC	4
Endrin	4	α-BHC	1
Dieldrin	5	Hexachlorobenzene	1
Heptachlor Epoxide	4	Oxychlordane	3

Table 3. Habitat components considered in bald eagle habitat selection analysis on the Lower Snake River, Wyoming.

Acronym	Habitat Component	GEOSCAN File Type
DRD	Paved Roads	Line
DRT	Gravel/dirt roads and trails	Line
STM	Permanent Streams to 1st order	Line
IMS	Intermittent Streams, at confluence with Snake River	Point
FED	Ungulate Feedgrounds	Area
VIL	Groups of 4 or more bldgs.	Area
HOW	Buildings	Point
RIV	Snake River	Area
ISL	Islands in Snake River	Area
DR	Deep Runs in Snake River	Line
DP	Deep Pools in Snake River	Line
SR	Shallow Runs in Snake River	Line
SP	Shallow Pools in Snake River	Line
RIF	Riffles in Snake River	Point
CGD	Developed Campgrounds	Area
CGU	Undeveloped Campgrounds	Area
PO	Pullouts on Highway	Point
RPO	Boat Landings	Point
WET	Wetlands and Marshes	Area
TIM	Timber Stands	Area
MED	Meadows in Timber	Area
PVT	Private Land	Area
LAK	Lakes	Area

Table 4. Variables included in calculation of a Lake Shoreline Diversity Index (LDI) for Jackson Lake, Grand Teton National Park, Wyoming.

Variable	Measurement/Availability LSS[1]	Relationship[2]	Indicator
Shoreline	Length (m)	+	Prey/habitat diversity
Timber Edge	Length (m) within 100 m of shore	+	Perches
Island Shoreline	Length (m)	+	Prey/habitat diversity
Developed Shoreline	Length (m), shoreline impacted by marinas, campgrounds, picnic and concentrated use areas	-	Human activity
Intermittent Streams	Number, confluence with Jackson Lake	+	Prey
Permanent Streams	Number, confluence with Jackson Lake	+	Prey
Islands	Number, within 200 m of shore or each other	+	Prey/habitat diversity
Depth	$\bar{x}$ distance[3], shore to next 25' bathametric contour	+	Prey

[1] LSS = Lake Shoreline Segments. Determined by shoreline included in 1600 m compass arc (see text).

[2] + = Tends to increase diversity, - tends to decrease diversity

[3] Determined from 4 sample points, 200, 600, 1000, 1400 m from origins of each LSS

Table 5. Bald eagles banded in the Greater Yellowstone Ecosystem by geographic area, 1979-1989.

Geographic Area	Number Banded Nestlings	 Captured[1]	 Total
Yellowstone National Park	31	--	31
Snake Teton	36	15 (6)	51
South Park & Lower Snake River	57	13 (6)[a]	70
Snake Idaho	78	3 (2)[b]	81
Continental Idaho	31	--	31
Continental Montana	24	--	24
Total	257	31 (14)[c]	288

[1] Residents.
[a] Includes 2 fledged juveniles and 1 rehabilitated adult.
[b] Includes 1 fledged juvenile.
[c] 10 breeding adults from 8 pairs.

Table 6. Bald eagles radio-tagged as nestlings in the GYE, 1985-1989.

Natal Nest	Geographical Area	Gender	Year Radio-tagged	Years Located[a]	Radio Freq[1]	Hours Monitored[2]
Cabin Creek	LSR	M	1985	4	.923	15
Dog Creek	LSR	F	1985	3	.975	15
Butler Creek	SP	F	1985	5	.700	8
Fords	SP	M	1985	1	.575	20
Moose	ST	M	1985	1	.823	10
Cabin Creek	LSR	F	1986	3	.500	56.5
Fords	SP	M	1986	1	.944	18.6
Schwabacher	ST	F	1986	1	.411[3]	118.5
Promontory	YU	M	1986	3	.640	5
Gros Ventre	SP	F	1987	2	.196	52
3rd Creek	ST	F	1987	3	.393	62.6
Eagle Bay	YU	F	1987	3	.927	*
Antelope	SI	M	1987	5[4]	.826	NA
Box Canyon	CI	F	1987	3	.875	NA
3rd Creek	ST	M	1988	1	.099	21
Elbow	LSR	F	1989	2	.412	5
Jardine	CM	M	1989	1	.011	@50

[a] Or known alive subsequent to radio-tagging.

[1] 148 mHz.

[2] Only during year of radio tagging.

[3] Changed to .600 when captured in Oregon in September 1986

[4] Located breeding on the Missouri River in Montana, summer 1991, 1992.

[*] Located by aircraft.

Table 7. Migrant and nonadult resident bald eagles captured in the GYE, by geographical area, 1985-1989.

Local Nest Site	Geographical Area	Age[1]	Gender	Date Captured	Residency Status[2]	Capture System[3]	Transmitter Freq[4]	Transmitter Mount[5]
Hoback	LSR	SA	F	1-11-86	M	LH	-	-
Dog Creek	LSR	SA	F	1-16-86	M	LH	-	-
Elk Refuge	ST[6]	A	M	1-23-86	M	LH	.650	TM
Sheep Gulch	LSR	FLED	M	8-12-86	N	BN	.499	TM
Schwabacher	ST	A	M	12-08-86	M	BN	.700	TM
Dog Creek	LSR	A	M[7]	12-22-86	M	BN	.825	TM
Dog Creek	LSR	A	F	2-19-87	M	BN	.827	TM
Oxbow	ST	SA	M	3-01-87	M	BN	-	-
Munger Mtn.	SP	FLED	M	6-06-87	N	BN	.260	TM
Hoffman	SI	FLED	F	8-04-87	N	BN	-	-
Gills	SP	SA	F	9-05-87	N	BN	-	-
3rd Creek	ST	A	M	12-06-87	M	BN	.411	BP
Gormer	SI	A	F	12-31-87	M	BN	.252	TM
Gros Ventre	ST	A	M	1-26-88	M	BN	.826	TM
Gros Ventre	ST	A	F[8]	2-04-88	M	BN	.100	TM
Oxbow	ST	A	M	3-14-88	M	BN	-	-
Pine Creek	SI	FLED	F	7-27-88	N	BN	-	-
Schwabacher	ST	FLED	M	8-10-88	N	PS	.388	TM

[1] FLED = fledgling; SA = subadult; NA = near adult; A = adult.
[2] M = migrant; R = resident; N = natal area.
[3] LH = padded leg-hold, BN = radio-controlled bownet; PS = radio-controlled. power snare.
[4] 148 mHz.
[5] TM = tail mount; BP = backpack.
[6] Captured in ST, but wintered in SP.
[7] Previously banded in Glacier National Park, MT, 10-14-80 as a 3 year old.
[8] Previously banded 17.5 m NNW, Evanston, WY, 2-20-81.

Table 8. Total time (hrs:min.) devoted to specific tasks involved in capture operations for resident bald eagles in the Snake Teton portion of the GYE only, from 1 October 1987 to 15 January 1989.

Target Bald Eagle (sex/age)	Preliminary Observations	Pre-Baiting	Capture Device			Total
			Prep.[1]	Setting[1]	Observation	
Third Ck. (male/adult)	0:00[2]	77:49	90:00	63:00	204:52	435:41
Oxbow (female/adult)	114:51	0:00	108:00	54:00	262:05	538:56
Schwabacher (male/adult)	20:48	85:33	18:00	9:00	106:54	240:15
Wilcox Point (male/adult)	0:00	20:02	3:00	3:00	2:15	28:17
Schwabacher (male/fledgling)	0:00	0:00	3:00	3:00	0:55	6:55
Total:						1250:04

[1] Hours are estimates from days expended.

[2] Movements and use areas were determined during tracking of mate, 29 Dec. 1986 to 6 August 1987.

Table 9. Adult bald eagles resident in the Snake Population Unit of the GYE captured and radio-tagged between 1985 and 1989.

Local Breeding Area	Geographical Area	Gender	Date Captured	Transmitter Freq[1]	Transmitter Mount[2]
Cabin Creek	LSR	M	2-28-86	.750	TM
Butler Creek	LSR	F	4-14-86	.700	TM
Sheep Gulch	LSR	M	8-12-86	.798	BP
3rd Creek	ST[3]	F	12-22-86	.700	TM
Schwabacker	ST	M	2-11-87	.575	BP
Oxbow	ST	M	3-1-87	.324	BP
Oxbow II	ST	M[4]	1-6-88	.318	BP
Wilcox Point	ST	M	2-18-88	.150	TM
3rd Creek	ST	M	6-19-88	.927	BP
Schwabacker[5]	ST	M	7-6-88	.262	BP
Pine Creek	SI	F	7-27-88	.070	BP
Oxbow	ST	F	8-17-88	.190	BP
Elbow	LSR	M	5-10-89	-[6]	-

[1] 148 mHz.

[2] TM = tail mount; BP = backpack.

[3] Eagle bred in ST but was captured in LSR.

[4] Disappeared 1 week after capture.

[5] Recaptured to replace malfunctioning transmitter.

[6] Expired in trap.

Table 10. Location, monitoring effort and home range size for 11 adult resident bald eagles radio-tagged in the GYE, 1985-1989.

Breeding Area	Study Area	Gender	Seasons Tracked[1]	Monitoring Time		Home Range Size[2] (No. Locations)
				Days	Hrs:min	
Sheep Gulch	LSR	M	PF,F,W	74	274:24[3]	17.84 (38)
Cabin Creek	LSR	M	EN,LN,PF	77	364:10	45.85 (125)
Butler Creek	SP	F	EN,LN	21	168:30	4.32 (32)
Schwabacher	ST	M	W,EN,LN,PF,F	164	462:57	4.08(244)
Oxbow	ST	M	EN[4]	25	122:04	11.73 (31)
Oxbow	ST	M	W	11	62:18	*[5] (18)
Oxbow	ST	F	F,W,EN,LN,PF	118	448:43	65.16 (177)
3rd Creek	ST	F	W,EN,LN	84	335:57	56.94 (108)
3rd Creek	ST	M	LN,PF,F,W,EN	131	606:12	374.66 (220)
				Breeding (EN,LN,PF)		114.74
Wilcox Point	ST	M	W,EN	54	383:34	120.28[6](167)
				Northern Winter range		20.49
				Southern Breeding range		43.3
Pine Creek	SI	F	W,EN,LN	NA[7]	NA	NA
			Total Monitoring	765	3228:54	

[1] W=Winter, EN=Early Nesting, LN=Lake Nesting, PF=Post fledging, F=Autumn, W=winter.
[2] Minimum convex polygon area, km^2.
[3] Includes 51.5 hrs visual monitoring prior to radio-tagging.
[4] Eagle shot.
[5] Abandoned territory, range not determined, possible migrant.
[6] Total range.
[7] Data Not Available.

Table 11. Location and monitoring effort for 12 non-adult and migrant bald eagles radio-tagged in the GYE, 1985-1989.

Breeding Area	Age[1]-Gender	Transmitter Freq[2]	Season(s) Tracked[3]	Time Monitored	
				Days	Hrs:min
Elk Refuge (SP)[4]	A-M	.650	W,EN	10	28:04
Sheep Gulch (LSR)	J-M	.499	PF	30	69:40
Dog Creek (LSR)	A-M	.825	W	1	3:00
Dog Creek (LSR)	A-F	.878	W	3	19:28
Munger Mtn (SP)	J-M	.260	PF,F,EN	26	64:00
3rd Creek (ST)	A-M	.411	W	2	13:52
Gormer (SI)	A-F	.252	W	3	0:35
Hoffman (SI)	J-M	.875	PF	12	11:58
Gros Ventre (SP)	A-M	.826	W	4	7:32
Gros Ventre (SP)	A-F	.100	W	13	124:24
Schwabacher (ST)	A-M	.700	W	21	122:15
Schwabacher (ST)	J-M	.388	PF,F	8	1:24
				123	466:12

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[1] A = adult; J = Juvenile.

[2] 148 mHz.

[3] W=Winter, EN=Early Nesting, LN=Lake Nesting, PF=Post fledging, F=Autumn, W=winter.

[4] GYE Population Unit.

Table 12. Monitoring effort and home range size for resident adult bald eagle pairs monitored visually in the Snake Population Unit of Wyoming, Greater Yellowstone Ecosystem, 1985-1989.

Pair Name	Hours Monitored	Inclusive Dates	No. Locations	Home Range Size (km^2)[2]
Hoback	115.5	03-06-86 through 04-12-87	86	21.31
Elbow	45.0	11-02-86 through 04-14-87	24	5.80
Ford's	8.5	01-23-87 through 04-10-87	11	*[3]
Dog Creek	325.0	05-01-85 through 04-10-87	57	8.25
Total	493.0			

[1] On Snake River.

[2] Minimum convex polygon area.

[3] insufficient Data.

Table 13. Encounter statistics of bald eagles banded in the GYE, 1979-1990.

Geographic Area of Origin	Total No. Banded	No. Encountered (%)[1]			No. Direct Encounters
		In GYE	Outside GYE	Total	
Yellowstone Unit (YU)	31	2 (7.4)	--	2 (7.4)	1
ST	51	3 (11.1)	3 (11.1)	6 (22.2)	4
SP & LSR	70	6 (22.2)	1 (3.7)	7 (25.9)	1
Snake Idaho (SI)	81	4 (14.8)	4 (14.8)	8 (29.6)	2
Continental Idaho (CI)	31	--	2 (7.4)	2 (7.4)	1
Continental Montana (CM)	24	1 (3.7)	1 (3.7)	2 (7.4)	1
Total	288	16 (59.3)	11 (40.7)	27 (9.4)	10 (37)
Percent of Total Banded		5.6	3.8	3.5	3.5

[1] Percent of total encountered.

[a] Percent of total banded.

[b] Percent encounter rate for all GYE banded eagles.

Table 14. Criteria for 27 encounters of bald eagles banded in the GYE, 1979-1990.

Encounter Agent	Number	Percent Banded	Percent Encountered
Unknown	8	3	33.3
Captured for Research	6	2	22.2
Gunshot	4	1.4	14.8
Poisoned (organophosphates)[1]	3	1	11.1
Leg hold trap	2	0.7	7.4
Lead (Pb) Poisoned	2	0.7	3.7
Electrocuted	1	0.3	3.7
Vehicle Impact	1	0.3	3.7
Total	27	100	99.9[a]

[1] Confirmed or strongly suspected (2).

[a] Error due to rounding.

Table 15. Sightings of GYE colorbanded bald eagles within the GYE by unit of origin and subsequent observation, 1979-1990.

Area Observed	Geographical Area of Origin								Total Banded[2] Seen
	SW[1]	ST	SI	CI	CM	YU	Not YU	Totals	
ST	4(20)[4]	4	5			3	4	20	28
SW	2	2(16.6)	4				4	12	19
SI		4	7(58)	1				12	12
CI	1	2	4	2(22.2)				9	13
CM			1	1		1	2	5	5
					Totals			58	77

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[1] SW includes SP & LSR.

[2] Includes eagles seen wearing just a USFWS band.

[a] No. in parentheses are % observed in natal area subsequent to year of banding.

Table 16. Reproductive performance of 21 pairs of bald eagles recorded in the Snake Wyoming portion of the Snake Population Unit of the GYE, 1978-1990.

	No. Years Known			Total Young	Young per	
Breeding Area	Occupied	Active	Prod.	Produced	Attempt	Occupied
Thayne	11	11	8	11	1.0	1.0
Sheep Gulch	9	6	1	1	0.17	0.11
Elbow	4	4	2	4	1.0	1.0
Cabin Creek	13	13	11	21	1.62	1.62
Dog Creek	12	11	11	18	1.64	1.64
Hoback	7	6	6	7	1.17	1.0
Munger Mtn.	4	3	3	4	1.33	1.0
Butler Creek	11	11	9	16	1.73	1.73
Gills	11	10	10	16	1.60	1.45
Fords	13	13	9	17	1.30	1.30
Elk Refuge	4	3	3	4	1.33	1.0
Gros Ventre	11	11	11	19	1.73	1.73
Slide Lake	9	4	2	3	0.75	0.33
Moose	13	12	6	11	0.92	0.85
Schwabacher	13	13	10	16	1.23	1.23
Triangle X	7	7	5	7	1.0	1.0
RKO	12	4	0	0	0	0
Buffalo Valley	5	4	3	3	0.75	0.6
Oxbow	12	11	6	7	0.64	0.58
3rd Creek	4	4	3	4	1.0	1.0
Wilcox Point	13	10	4	4	0.4	0.31
TOTAL	198	171	123	193	1.13	0.97

Table 17. Productivity of bald eagles nesting in the Wyoming portion of the Greater Yellowstone Ecosystem (Snake Unit), by geographic area, 1985-1989.

Geographical Area	No. Pairs (% of SU)	Productivity[1]	Young Produced No.	Young Produced %[2]
LSR	5 (26.3)	1.47	28	31.5
SP	6 (31.6)	1.30	34	38.2
Total, Snake Wyoming	11 (57.9)	1.38	62	69.7
Snake River (ST)	6 (31.6)	1.0	23	25.8
Jackson Lake (ST)	2 (10.5)	0.5	4	4.5
Total, Snake Teton	8 (42.1)	1.04	27	30.3

[1] Young per occupied nest

[2] % of total produced in SU of Wyoming (89)

Table 18. Nesting phenology of bald eagles in the Snake Population Unit, Wyoming of the GYE, 1985-1989.

Geographical Area	Egg Laying		Fledging	
	Median Date (N)	Range	Median Date (N)	Range
LSR	7 March (13)	3/4-3/22	13 July (12)	7/6-8/6
SP	12 March (12)	2/24-4/4	16 June (7)	6/15-7/19
Snake River (ST)	26 March (12)	3/22-4/4	22 July (6)	7/16-7/25
Jackson Lake (ST)	29 March (5)	3/22-4/10	23 July (3)	7/20-8/17

Table 19. Circumstances of loss of breeding adult male bald eagles in 5 breeding areas in the Greater Yellowstone Ecosystem.

Breeding Area	Date Lost	Date Replaced[1]	Cause of Loss	Replacement Period
Sheep Gulch[2]	12-20-86[3]	3-01-87	Intraspecific Conflict	10 weeks
Elbow[2]	5-19-89	8-30-89	Trap Mortality	14.7 weeks
Oxbow	4-11-87	3-01-88	Gunshot	49.4 weeks
Wilcox Point	1-30-89	2-15-89	Unknown	2 weeks
Elk Lake	9-28-89	by March 1990	Gunshot[3]	max. 5 months

[1] Date of first observation of adult male near nest.

[2] Siblings fledged in 1980, bred in adjacent breeding areas.

[3] Not confirmed but strongly suspected.

Table 20. Bald eagles detected in years subsequent to radio-tagging as juveniles in the GYE, 1985-1989.

Year	No. Detectable[1]	No. Detected (% of original cohort)			
		2nd Year	3rd Year	4th Year	5th Year
1985	5 (5)	4 (80)	3 (60)	2 (40)	1 (20)
1986	4 (5)	3 (75)	2 (50)	-	*
1987	6 (7)	6[a](100)	4 (67)	1[b](17)	1[c]
1988	1 (4)	1 (100)	*	*	*
1989	0 (1)	*	*	*	*
Total	16 (22)	14 (87.5)	9 (60)	3 (33.3)	1 (20)

[1] Number adequately searched for to determine presence or wearing permanent radio packages, total marked in parentheses.

[a] Includes one eagle wearing tailmount radio, detected following year.

[b] Not detected in 3rd year but seen in 4th year.

[c] Seen breeding in 1991, 1992.

*No searches.

Table 21. Annual survival by age class of bald eagles radio-tagged in the GYE, 1985-1989.

Years from Radio-tagging (Age)	No. Detectable		No. Detected	Survived[1]	
	Max[2]	Probable[3]		Min[4]	Max[5]
1	17	17	14	82.4	82.4
2	13[a]11	10	76.9	90.9	
3	12	9	6	50.0	66.7
4	5	4	3	60.0	75.0
5	3	1	1	33.3	100.0

[1] From previous year.

[2] Total radio-tagged minus known mortalities, transmitter losses or malfunctions.

[3] Calculated from [2] above less those not detected the previous year.

[4] Calculated from [2] above.

[5] Calculated from [3] above.

Table 22. Length of shoreline of Snake River and lakes included in home range polygons of bald eagles nesting in the Snake Wyoming and Snake Teton portions of the Greater Yellowstone Ecosystem, 1986-1989.

Eagle Home Range	Length of Shoreline (km)			
	River	Lakes	Island[1]	Total
Sheep Gulch	17.12	2.26		19.38
Elbow[2]	10.58		0.74	11.32
Cabin Creek	33.47 (11.12)[a]		10.65 (9.91)	44.12 (21)
Dog Creek[2]	7.64		7.95	15.59
Hoback[2]	25.82[b]		0.78	26.60
Butler Creek	8.43		8.0	16.43
Schwabacher	32.20	9.59	11.27	53.06
Oxbow Male	18.28		3.86	22.14
Oxbow Female	39.40[c]	12.22	9.42	61.04
Third Creek Male (southern breeding range)				
Low[3]		43.7	15.12	58.82
Medium		48.75	17.57	66.32
High		45.44	20.17	65.61
Third Creek Female[4]	17.73	32.68	13.35	63.76
Wilcox Point	54.93	4.81	3.90	63.64
Northern Winter Range				
	8.86		1.84	10.70
Southern Breeding Range				
	28.82	4.81	0.34	33.97

[1] Includes islands in both Snake River and lakes.

[a] Estimated length after initiation of Elbow territory.

[b] Includes portion of Hoback River.

[2] Non-radio-tagged pair, range includes locations of male and female.

[3] Water level of Jackson Lake.

[4] Medium water level on Jackson Lake.

Table 23. Mean Lake Shoreline Diversity Index (LDI) for Lake Shoreline Segments (LSS) of Jackson Lake, Wyoming at different water levels.

Water Level	Mean Elevation (meters)	Mean LDI	No. LSS	SD	Levels Different at P <0.00
A. High	2057	1.773	48	1.692	B,C
B. Medium	2055	1.375	40	1.241	A,C
C. Low	2053	0.855	35	0.723	A,B

Table 24. Recreational boat traffic on 2 sections of the Lower Snake River portion of the GYE, 18 July - 28 August 1987. Data are mean or median values.

Use Category	River Section	
	Upper[1]	Lower[2]
Incidents[3] per Day	10.83	63.7
Watercraft per Incident	1.5	2.4
Duration of Incident	3.8	3.1
Interval Between Incidents[4]	46.3	9.8
Watercraft per Day	18	154
People per Day	45	758
Concession Craft per Day	1.5	41
Time of First incident	0800 hrs.	0900 hrs.
Daylight Hours per Day Boats Present[5]	0.72	3.2
Daylight Hours per Day Boats Absent	13.4	9.4

[1] Sampled from Astoria (RMS 22) to Elbow (RMS 15).

[2] Sampled from Elbow to Sheep Gulch (RMS 4).

[3] Incident = no. minutes boats in continuous view of camera.

[4] Interval = no. minutes no boats in view of camera.

[5] Within camera view.

Table 25. Distances at which bald eagles flushed from human activity, Lower Snake River (LSR) portion of the GYE, 1985-1987.

	Flushing Distance (m) From:									
	Vehicles			Pedestrians			Watercraft		Misc.	
Breeding Area[1]	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	N	$\bar{x}$
Sheep Gulch	5	240.8	310	7	81	40.1	2	30	1[2]	122
Elbow	2	118	80.6							
Cabin Creek	1	30	-	2	175	205.1				
Dog Creek	1	69	-						1[3]	0
Hoback	1	11	-							
All	10	155.5	217.89	96.3	87.1	2	30	0	2	61(86.3)

[1] Includes observations of resident and migrant eagles.

[2] Vehicle backfire.

[3] Flush from unsuccessful trapping attempt.

Table 26. Distances of 40 encounters when bald eagles flushed from human activity, Snake Teton portion of the Greater Yellowstone Ecosystem, 1987-1989.

	Flushing Distance (m)								
	Vehicles			Pedestrians			Watercraft		
Breeding Area[1]	N	x̄ (Range)	SD	N	x̄ (Range)	SD	N	x̄ (Range)	SD
Third Creek				4	84 (60-137)	36	14	155 (25-537)	127
Oxbow	6	355 (125-685)	187	6	258 (40-400)	165			
Schwabacher	1	183	-	6	215 (50-402)	164	1[•]		
Wilcox Point	2	200	0	1	1600				

[•] Eagle flushed off of ground, distance unknown.

[1] Includes observations of resident and migrant eagles.

Table 27. Distribution of encounters between resident eagles and humans recorded in the Wyoming portion of the Greater Yellowstone Ecosystem.

	No. Resulted In:		
Area (Acronym)	Flush	Nonflush	% Total (N)
Lower Snake River (LSR)	22	28	39.7 (50)
South Park (SP)	5	16	16.7 (21)
Snake Teton (SP)	23	32	43.6 (25)
TOTAL	50	76	126

Table 28. Mean distance (m) at which resident bald eagles flushed from human activity of all types in selected areas of the GYE, 1985-1989.

Area (Acronym)	Mean Distance	SD	(N)	95% CI
Lower Snake River (LSR)	120.0	165.3	22	±73.3
South Park (SP)	208.8	335.8	5	±416.7
Snake Teton	232.0	166.0	23	±55.6
River Only	312.6	171.4	11	±115.1
Lake Only	158.2	126.2	12	±80.3
All Areas	180.6	190.3	50	±54.1

Table 29. Overall foraging success of resident adult bald eagles radio-tagged in the Snake Teton portion of Greater Yellowstone Ecosystem, 1987-1989.

	No. Attempts (N=95)			
Eagle	Successful	Unsuccessful	Unknown	% Success
Oxbow Male	2	3		40
Third Creek Female	5	2		71
Wilcox Male	4	12		25
Third Creek Male	9	2	3	81.8
Schwabacher Male	11	8		57.9
Oxbow Female	21	10	3	61.7
ALL	52	37	6	54.7

Table 30. Actual and predicted (logit regression) distances of bald eagle foraging attempt locations from most recently active bald eagle nests for 50 and 90 cumulative percent level.

		Forage Site to Nest				
		50% Distance (m)		90% Distance (m)		
Eagle[a](gender)	N	Actual[b]	Calculated	Actual	Calculated	R^2
Sheep Gulch (M)	43	5,274	5,196	6,881	6,738	97
Elbow	3	215	*	298	*	*
Cabin Creek (M)	19	1,877	1,774	2,650	3,030	98
Dog Creek pair	10	120	256	524	578	96
Hoback pair	10	2,700	2,069	4,200	4,535	82
Butler Creek (F)	5	292	326	667	584	93
Schwabacher (M)	20	1,287	3,413	8,315	8,487	69
Oxbow (F)	21	1,554	1,776	4,344	3,809	94
Oxbow (M)	3	634	*	1,489	*	*
Third Creek (M)	12	3,631	3,989	6,763	7,093	96
Third Creek (F)	7	2,679	2,869	6,351	4,561	75
Wilcox (M*87)	8	658	918	4,947	2,250	78
Wilcox (M*88)	8	1,504	1,518	5,789	2,529	94

[a] Eagles not shown as male (M) or female (F) were visually monitored as pairs and data for both sexes were lumped. Wilcox (M) is separated by years because different nests were used during different years.

[b] Some actual distances are interpolations between percent levels.

*Insufficient data for calculation.

Table 31. Actual and predicted (logit regression analysis) proximity of preforaging perch to foraging location for 50% and 90% of foraging events of adult bald eagles resident in the Snake Wyoming portion of the Greater Yellowstone Ecosystem.

			50% Distance (m)		90% Distance (m)		
Eagle[a](gender)	N	Habitat	Actual[b]	Calculated	Actual[b]	Calculated	R^2
Sheep Gulch (M)	43	River	238	414	1,151	946	85
Elbow	3	River	118	*	130	*	*
Cabin Creek (M)	17	River	285	401	916	875	88
Dog Creek pair	10	River	393	380	786	814	99
Hoback	10	River	60	32	392	331	98
Butler Creek (F)	5	River	330	352	637	584	99
Schwabacher (M)	19	River	94	94	286	272	99
Oxbow (F)	24	River	103	120	600	375	94
Oxbow (M)	3	River	152	*	152	*	*
Third Creek (M)	12	Lake	285	389	1,151	972	87
Third Creek (F)	6	Lake	1,725	1,494	2,606	2,857	89
Wilcox (M)	11	Lake	347	425	975	789	89

[a] Eagles not identified to gender were visually monitored as pairs and data for both eagles combined.

[b] Some distances interpolated.

*Insufficient data for calculation.

Table 32. Important habitat component variables selected by Stepwise Discriminant Analysis for discriminating between FORAGE site location and locatons of nonuse, incorporating different habitat components and location scenarios.

Scenario Number	Foraging Locations Included[1]	Habitat Components Included[2]	Most Discriminating Components[3]	ISR[4]	Patials[5] R^2
1	ALL	ALL	NEST	+	.46
			HOW	-	.14
			PVT	+	.10
			PRD	-	.05
			RIV	+	.04
			DR	-	.12
			DP	-	.05
			IMS	-	.03
2	For all eagles not including LAK component in home range	ALL	NEST	+	.45
			SR	+	.24
			HOW	-	.13
			RIV	+	.04
			RIF	+	.03
			DP	-	.03
			STM	+	.04
			DRD	+	.05
			VIL	0	.04
			IMS	-	.02
3[a]	For all eagles not including LAK in home range	STM	ISL	+	.24
		IMS	DR	+	.06
		ISL	DP	-	.05
		DR & DP	IMS	-	.05
		RIF	STM	+	.04
		SR & SP			
4[b]	ALL	STM	STM	-	.14
		IMS	IMS	-	.04
		ISL	ISL	-	.02
		DR & DP	DR	-	.05
		RIF	DP	+	.03
		SR & SP			
		LAK			

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[1] Radio-tagged eagle or eagle pair observed.

[2] Of habitat components listed in Table 39.

[3] Distinguishing between used and nonused FORAGE locations, and order of entry.

[4] ISR = implied selection relationship + = selected for, - = avoided, 0 = neutral

[5] Roughly equivalent to percent variation explained.

[a] Analysis includes lotic (river) associated habitat components only.

[b] Analysis includes lentic (lake) and lotic habitat components only.

Table 33. Mean minimum distance (meters) among bald eagle FORAGING locations (N = 108) and nonuse locations (N=44) and respective habitat components, resultant t-test p values and ISR[2]. Data presented are for those ranges that included the Snake River only and all ranges (included river & lake components).

	Mean Minimum Distance			T-Test P Value[3]	
	Use				
Habitat Component[1]	River (ISR)[2]	All (ISR)[2]	Nonuse	River	All
PRD	24.1 (-)	40.4 (-)	20.9	.028 *	.000 *
DRD	82.2 (+)	71.9 (+)	187.9	.001 *	.000 *
WET	200.8 (-)	1340.4 (-)	780.4	.000 *	.000 *
STM	39.7 (+)	183.6 (-)	93.9	.000 *	.000 *
RIV	1.1 (+)	36.6 (+)	44.7	.000	.482
IMS	53.0 (-)	72.6 (-)	42.2	.017 *	.000 *
VIL	353.6 (0)	178.6 (+)	366.7	.861 *	.005 *
FED	3377. (+)	270.1 (+)	453.4	.072	.002 *
CGU	130.3 (+)	166.6 (-)	161.6	.161	.803
CGD	236.7 (+)	146.8 (+)	256.7	.697	.016 *
PO	52.9 (+)	53.4 (0)	57.7	.603	.596
ISL	75.4 (+)	1088.9 (-)	547.8	.000 *	.000 *
HOW	394.8 (-)	507.2 (-)	256.3	.000 *	.000 *
RPO	120.2 (-)	136.6 (-)	113.9	.657	.105
DR	30.3 (+)	146.2 (-)	30.5	.987	.000 *
DP	59.6 (-)	69.5 (-)	44.1	.117	.005 *
RIF	29.0 (+)	50.0 (-)	36.0	.171	.007 *
SR	145.7 (+)	1319.3 (-)	710.1	.000 *	.000 *
SP	644.4 (-)	1024.4 (-)	213.1	.000 *	.000 *
TIM	11.6 (+)	42.6 (-)	14.5	.459	.000 *
MED	69.7 (+)	114.2 (-)	73.2	.709	.000 *
PVT	47.5 (+)	41.2 (+)	22.3	.000 *	.000 *
LAK	--	868.0 (+)	1482.6	--	.000 *
NEST	12.7 (+)	26.6 (+)	218.4	.000 *	.000 *

[1] See Table 3 for explanation of habitat acronyms.

[2] ISR = Implied Selection Relationship for use locations. + = selection for - = avoidance, 0 = neutral.

[3] * = considered statistically or biologically significant.

Table 34. Mean River Diversity Index (RDI) of River Mile Segments (RMS) with and without bald eagle nest sites along the Snake River, Wyoming.

Geographical Area	Mean RDI	
	Nest RMS (N)	All other RMS (N)
Lower Snake River[1] (LSR)	0.92* (5)	0.6 (21)
South Park (SP)	10.12 (5)	9.26 (14)
Snake Teton (ST)	9.94* (5)	6.82 (26)

[1] RDI for LSR calculated differently than for SP and GTNP.

*Indicates difference significant at the $P \leq 0.05$ level for LSR and $P = 0.1326$.

Table 35. Comparison of Habitat Suitability Indexes (HSI) for River Mile Segments with and without bald eagle nests in the Snake Unit, Wyoming portion of the GYE, 1989.

Geographical Area	Mean HSI		P Value
	With Nests(SD)	Without Nests(SD)	
Lower Snake River[1]	6.028 (5.506)	3.784 (3.815)	0.3473
South Park (SP)	7.516 (4.224)	3.261 (2.273)	0.0577
Snake Teton (ST)	8.404 (3.573)	4.268 (2.592)	0.0225

[1] HSI calculated differently than for SP and ST, see Methods.

Table 36. Results of nonparametric Mann-Whitney rank sum tests for minimum distance between respective habitat components of weighted bald eagle NEST site locations (N=36) and locations of nonuse (N=24).

	Median Distance[2]		
Habitat Component[1]	Use	Nonuse	P Value
PRD	21.97	66.0	.0000
DRD	72.9	104.6	.3502
RIV	7.216	62.009	.0000
DP	46.16	94.45	.0000
VIL	291.5	195.0	.6076
HOW	639.9	387.1	.0000
ISL	187.0	403.6	.0000
STM	29.3	61.75	.019
PVT	48.34	109.71	.2092
MED	46.11	75.55	.0255
TIM	1.38	2.38	.3376
SP	46.23	657.02	.0000
SR	79.79	669.11	.0005
CGD	161.22	140.15	.3015
RPO	56.47	124.57	.0055
PO	34.93	77.03	.0002
CGU	140.9	143.52	.049
FED	328.54	324.23	.0699
IMS	55.65	85.94	.0044
WET	37.46	663.91	.0000
LAK	1090.5	781.4	.0001

[1] See Table 3 for explanation of acronym.

[2] In decameters (meters x 10).

Table 37. Important habitat component variables selected by Stepwise discriminant Analysis for discriminating between used and nonused bald eagle NEST locations.

Habitat Variable[1] (Order Entered)	Partial R^2 Value[a]	Implied Selection Relationship[2]
RIV	.50	+
HOW	.44	--
RIF	.42	+
MED	.18	+
PO	.04	+
CG	.06	+
CGD	.05	+
PVT	.07	+
FED	.09	+
PRD	.06	+

[1] See Table 3 for explanation of habitat variable acronym.

[a] Roughly equivalent to % variation explained.

[2] + = Selected for, -- = avoided.

Table 38. Actual and predicted (logit regression) proximity of bald eagle perches from most recently active bald eagle nests for 50 and 90 cumulative percent level.

	Perch to Nest					
	50% Distance (m)			90% Distance (m)		
Eagle[a](gender)	Actual	Calculated	R^2	Actual	Calculated	R^2
Sheep Gulch (M)	4,300	4,439	98	5,874	6,124	98
Cabin Creek (M)	1,800	1,854	97	5,200	4,957	97
Dog Creek pair	550	540	98	1,390	1,286	98
Hoback pair	3,150	774	89	3,210	3,207	89
Butler Creek (F)	800	610	95	1,800	1,549	95
Schwabacher (M 87-88)	1,580	2,462	91	8,220	8,123	91
Schwabacher (M 89)	441	678	89	2,788	2,784	89
Oxbow (F)	1,700	1,774	98	4,335	4,067	98
Third Creek (M)	3,583	4,394	97	9,950	9,150	97
Third Creek (F)	1,700	1,713	99	3,575	3,715	99
Wilcox (M-87)	805	1,253	87	5,280	4,275	87
Wilcox (M-88)	1,400	1,675	91	5,400	4,063	91

[a] Eagles not shown as male (M) or female (F) were visually monitored as pairs and data for both sexes were lumped. Schwabacher (M) and Wilcox (M) are separated by years because different nests were used during different years.

Table 39. Amount of selected habitat components in bald eagle home ranges, Lower Snake River, Wyoming.

	Sheep Gulch		Cabin Crk/Elbow[1]		Dog Crk		Hoback	
Habitat Component	No.	Length/[2] Area	No.	Length/ Area	No.	Length/ Area	No.	Length/ Area
Riffles	11		16		11			14
Deep Runs	17	6290	14	5838	8	3778	12	1107
Deep Pools	15	6204	21	5454	5	1228	6	178
Shallow Runs	5	1064	13	2607	5	2253	2	42
Shallow Pools			4	1142	3	554		
Islands (dm^2)			20	2878	13	3153	1	144
River (km)	2	16	1	13.4	1	6.13	1	14.6

[1] Undocumented Elbow range boundaries require combining with Cabin Creek.

[2] Length = meters, Area = decameters^2.

Table 40. Important habitat component variables selected by Stepwise Discriminant analysis for discriminating between used (weighted) and nonused bald eagle PERCH locations. Remaining 16 habitat components added less than 1 % of variance explained each.

Habitat Variable[1] (Order Entered)	Partial $R^2(\%)^2$	Implied Selection Relationship[3]
NEST	.33	+
HOW	.22	--
WET	.07	+
PVT	.04	+
CGU	.02	+
RIV	.01	+
PRD	.01	--
DR	.01	+
Total	.71	

[1] See Table 3 for explanation of habitat acronym.

[2] Roughly equivalent to % variation explained.

[3] + = Selected for, -- = avoided

Table 41. Mean minimum distance (meters), location to habitat component between weighted bald eagle PERCH location (N=644) and respective nonuse locations (N=300), resultant students t-test p value, and Implied Selection Relationship.

	Mean Minimum Distance			
Habitat Component[1]	Use	Nonuse	Implied Selection Relationship (ISR)[2]	P Value[3]
PRD	33.5	29.6	--	.52
DRD	92.3	200.2	+	.000 *
WET	424.1	810.1	+	.000 *
STM	62.2	88.4	+	.000 *
RIV	12.0	25.8	+	.000*
IMS	57.5	55.4	--	.479
VIL	373.7	419.4	+	.085
CGU	114.9	147.4	+	.000 *
CGD	211.9	218.0	+	.729
PO	49.4	45.2	--	.027 *
ISL	254.6	562.4	+	.000 *
HOW	452.6	267.5	--	.000 *
RPO	127.2	104.0	--	.000 *
DR	47.9	54.7	+	.215
DP	45.9	56.9	+	.003 *
RIF	52.6	44.4	--	.000 *
SR	368.2	738.3	+	.000 *
SP	370.5	628.3	+	.000 *
TIM	10.9	14.1	+	.066 *
MED	63.8	74.1	+	.007 *
PVT	83.4	247.6	+	.000 *
LAK	1842.1	1477.5	--	.000 *
NEST	49.9	151.7	+	.000 *

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[1] See Table 3 for explanation of habitat acronyms.

[2] + = Selected for; - = avoided.

[3] * = Considered statistically and/or biologically significant

Table 42. Correlation of seasonal use area weights with mean Lake shoreline Diversity Index (LDI) of all Lake Shoreline Segments included for adult bald eagles nesting at the Third Creek site, Jackson Lake, Wyoming, 1987-1989.

Third Creek Eagle	Season[1]	Lake Water Level[2]	Mean		r	P Value
			LDI	Use Area Weight		
Male	W	Low	1.235	0.097	-0.651	0.1132
	EN	Low, High	0.48[a]	0.74	-[a]	–
	LN	Medium	3.004	0.199	-0.225	0.592
	PF	Medium, Low	3.428	0.139	-0.096	0.8376
	F	Low	0.876	0.172	0.66	0.802
Female	EN	Medium	1.573	0.133	-0.287	0.713
	LN	Medium	0.628	0.251	0.048	0.939

[1] W=winter, EN=early nesting, LN=late nesting, PF=post-fledging, F=autumn; see METHODS, Use Area Description for season dates.

[2] See METHODS, Lake Shoreline Diversity Index for surface elevation.

[a] Only one use area intersected shoreline.

Table 43. Mean Weather Severity Index (WSI) by year associated with 4 weather recording stations along the Snake River, Wyoming, 1985-1989.

Weather Station	WSI				
	1985	1986	1987	1988	1989
Jackson (SP)[1]	97.1	8.1	45.5	46.3	42.7
Moose (ST)	148.7	64.0	84.2	123.0	110.5
Moran (ST)	170.2	113.2	96.0	123.0	153.0
South Gate (YU)	304.4	228.8	90.3	218.9	313.0

[1] Population Unit in Greater Yellowstone Ecosystem.

Table 44. Annual productivity of bald eagles in the Snake population unit, Wyoming and associated annual and monthly Weather Severity Index (WSI).

		WSI				
Year	Productivity	FEB	MAR	APR	MAY	MEAN
1985	1.11	411.9	381.84	46.17	-6.36	178.14
1986	1.0	358.7	154.32	43.8	4.76	105.47
1987	1.58	361.72	104.12	7.4	-7.21	78.3
1988	1.31	284.69	260.45	30.86	-4.18	125.39
1989	0.69	341.96	254.01	74.1	-3.12	145.89

Table 45. Mean productivity of bald eagles and associated mean Weather Severity Index (WSI) in areas exposed to similar weather patterns, 1985-1989, Snake River, Wyoming.

			Pearson Correlation		
Area[1]	Mean Productivity[2]	WSI	Coef.	R^2	P
Jackson	1.54	48.46	0.05	-	0.81
Moose	1.3	107.24	0.03	-	0.83
Moran	0.94	130.77	0.71	0.5	0.0002
South Gate	0.2	238.65	-0.88	0.77	0.05

[1] See Figure 4 for geographic location.

[2] Young per occupied site. One nest site (RKO) was eliminated from calculations due to uncertainty of occupancy and tradition of no production.

Table 46. Correlation analysis of percent of River Mile Segments (RMS) within bald eagle home ranges that had $\geq 80\%$ perching habitat remaining[1] with respective bald eagle productivity. Productivity expressed as young per occupied breeding area, 1985-1989.

Geographical Area	Mean		Mean Productivity	Correlation Coefficient(*r*)	P Value
	CEM[1]	RDI[2]			
Lower Snake River	38.2	0.8	1.07	0.75	0.24
South Park	25.3	9.4	1.44	0.21	0.79
Snake Teton[3]	54.2	7.0	0.92	0.98	0.16

[1] Calculated by Cumulative Effects Model (CEM) (Montopoli and Anderson 1991).

[2] RDI calculated differently for LSR and SP-ST.

[3] One home range (RKO) eliminated from calculations due to uncertainty of occupancy and tradition of no production.

Table 47. Results of correlation analyses of mean Habitat Suitability Index (HSI) with total young produced per breeding area for bald eagles nesting along the Snake River, Wyoming, 1978-1990. Mean HSI was calculated from HSI values of each River Mile Segment included in respective home ranges.

Geographical Area	Mean HSI[1]	Mean Total Productivity[2]	Pearson Correlation	P Value
Lower Snake River (LSR)	46.37	10.2	0.80 (0.65)	0.10
South Park (SP)[3] and Snake Teton (ST)[4]	10.52	11.75	0.72 (0.52)	0.44

[1] Calculation of variables included in HSI differed between LSR and SP-ST.

[2] Total young fledged for all occupied breeding areas divided by number of breeding areas in respective geographical areas.

[3] Gros Ventre pair omitted because of recorded use of the Gros Ventre River.

[4] One home range (RKO) eliminated from calculations due to uncertainty of occupancy and tradition of no production.

Table 48. Comparison of Habitat Suitability Indexes (HSI) of River Mile Segments (RMS) included in home ranges of bald eagle pairs exhibiting high and low productivity. Productivity is expressed as young produced per RMS, 1978-1984.

Study Area	Production Category	Mean HSI[1]	Young per RMS	P Value[2]
Lower Snake River (LSR)	High	9.365	6.0	
	Low	3.01	0.42	0.0072
South Park (SP)	High	7.81	6.75	
	Low	3.341	2.5	0.0224
Snake Teton (ST)	Low[3]	4.95	1.37	

[1] Calculated differently for LSR.

[2] Of difference between high and low.

[3] All production in ST considered low.

Table 49. Results of multiple regression analysis of productivity per occupied breeding area (1978-1990) with respective logit regression curve characteristics of groups of breeding adult bald eagles. X^1 = slope of logit curve at the 50% level, X^2 = distance at which 50% of cumulatitve perches occur from most recently active nest (see *Perch to Nest Distance*).

Sample (N)	Model Equation	R^2	P value
All Males (6)	$[2.059+(-22.18)X^1]+[(-0.02)X^2]$	0.632	0.223
All Males+Pairs[a] (8)	$[1.39+(-5.89)X^1]+[(-0.0129)X^2]$	0.16	0.65
All Females (3)	$[-11.0+(167.83)X^1]+[(0.426)X^2]$	0.99	<0.000
All Females+Pairs (5)	$[1.014+(9.532)X^1]+(-0.028)X^2]$	0.89	0.105

[a] Includes Hoback and Dog Creek pairs.

Table 50. Contaminant loads in tissue of 2 nestling bald eagles recovered dead in Horse Butte nest in southwestern Montana, 26 June 1981.

Specimen/Weight/Compound	Concentration, ppm wet weight Carcass	 Liver	 Brain
Male, 3400 grms			
p, p' DDE	0.75		0.08
Lead		0.25	
Copper		23.0	
Zinc		25.0	
Iron		290.0	
Mercury		1.80	
Selenium		0.82	
Cause of Death: Trauma			
Female, 3050 grms			
p, p' DDE		0.14	
Lead		0.41	
Copper		35.0	
Zinc		31.0	
Nickel		0.43	
Iron		370.0	
Chromium		0.076	
Mercury		1.70	
Selenium		2.40	
Cause of Death: Undetermined			

Table 51. Percent of non-nestling resident and migrant bald eagles sampled in the Greater Yellowstone Ecosystem that exhibited detectable levels of lead (Pb), mercury (Hg) and selenium (Se) in whole blood and mean concentration detected (ppm wet weight), 1985-1989. Mean concentration for entire sample tested is shown in parentheses.

Residency Status	(N)	Pb	Hg	Se
All Residents	(17)[a]	35.3% - 0.13 (0.04)	100% - 1.61[a,b]	100% - 3.21[a,c]
Adults	(11)[a]	45.5% - 0.13 (0.06)	100% - 2.40[a,d]	100% - 3.32[a,e]
Fledglings	(5)	20.8% - 0.10 (0.02)	100% - 0.50	100% - 3.19
Immatures	(2)	50.0% - 0.10 (0.05)	100% - 2.40	100% - 1.45
All Migrants	(10)	90.0% - 1.66 (1.50)	100% - 1.61	100% - 1.27

[a] Includes one resident adult captured and tested twice.

[b] N = 14.

[c] N = 15.

[d] N = 8.

[e] N = 9.

Table 52. Percent of nestling bald eagles sampled in the Greater Yellowstone Ecosystem that exhibited detectable levels of lead (Pb), mercury (Hg) and selenium (Se) in whole blood and mean concentration detected (ppm wet weight), by population unit, 1985-1991. Mean concentration for entire sample tested is shown in parentheses.

Population Unit	(N)	Pb	Hg	Se
Snake Wyoming	(21)	47.6% - 0.38(0.18)	100%[a] - 0.38	100%[a]- 1.71
Snake Teton	(20)	50.0% - 0.13(0.07)	95.0% - 0.28(0.26)	100% - 1.13
Snake Idaho	(39)	23.7% - 0.30(0.07)	100% - 0.23	100% - 1.59
Continental Idaho	(15)	6.60% - 0.20(0.01)	53.3% - 0.19(0.10)	100% - 1.89
Continental Montana	(6)	33.3% - 0.14(0.05)	50.0% - 0.23(0.12)	100% - 0.71
Yellowstone	(16)	18.8% - 0.12(0.02)	100% - 0.31	100% - 0.68
Greater Yellowstone	(119)	30.3% - 0.25(0.07)	89.7%[b]- 0.29(0.26)	100%[b]- 1.37

[a] N = 18.

[b] N = 116.

Table 53. Percent of nestling bald eagles sampled in the Greater Yellowstone Ecosystem that exhibited detectable levels of lead (Pb), mercury (Hg) and selenium (Se) in whole blood and mean concentration detected (ppm wet weight), 1985-1991. Mean concentration for entire sample tested is shown in parentheses.

Year	Pb	Hg	Se
1985	(3) 100% - 0.18	-[a]	-[a]
1986	(11) 27.3% - 0.78 (0.21)	100% - 0.38	100% - 0.94
1987	(54) 24.0% - 0.26 (0.06)	94.4% - 0.31(0.29)	100% - 1.24
1988	(36) 19.4% - 0.23 (0.04)	80.6% - 0.22(0.18)	100% - 1.78
1989	(8) 37.5% - 0.50 (0.13)	100% - 0.39	100% - 1.44
1990	(1) 100% - 0.17	-[a]	100% - 0.56
1991	(6) 100% - 0.07	83.3% - 0.70(0.60)	100% - 0.98

[a] None analyzed.

Table 54. Seasonal lead (Pb), mercury (Hg) and selenium (Se) concentrations (ppm wet weight) in blood of an adult male bald eagle associated with the Schwabacher breeding area, Grand Teton Nat'l. Park WY.

Season (Date)	Pb	Hg	Se
Winter (02-11-87)	0.21	1.9	7.0
Summer (07-06-88)	0.00	2.3	2.0

Table 55. Results of multiple regression analyses involving 3 scenarios of bald eagle perch weight calculation (dependent variable), River Diversity Index (RDI) and percent perching and foraging habitat remaining from cumulative effects of human activity (CEM). Bald eagles involved were radio-tagged and nesting on the Snake River in South Park and Grand Snake Teton portions of the Greater Yellowstone Ecosystem, 1987-1989.

Analysis Scenario	Independent Variables	F value	P value	R^2
Sum of all perch weights per RMS[1]	Perch CEM[2], RDI[2]	0.89	0.43	0.12
	Forage CEM[2], RDI[2]	0.729	0.50	0.10
Seasonal RMS weight[3]	Perch CEM, RDI	1.82	0.20	0.22
	Forage CEM, RDI	.307	0.303	0.17
Seasonal perch weight[4] for Schwabacher Male	*Time Specific Perch CEM, RDI	7.78	0.05	0.77
	Overall[5] Forage CEM, RDI	3.988	0.08	0.57

[1] RMS = River Mile Segment.

[2] Total of all perch weights for all seasons, all hours monitored.

[3] RMS weight calculated for perches used only between late nesting and post-fledging season.

[4] Calculated weights used only in late nesting through post-fledging seasons, between 0800 and 1700 hrs. CEM and RDI values assigned to each perch independent of RMS located.

*Best model for predicting perch use.

[5] Overall CEM and RDI regressed with seasonal RMS weight.

Table 56. Time expended searching for and tracking juvenile and immature bald eagles in South Park Wyoming between 26 June 1986 and 15 June 1988, number of perches detected and maximum frequency of individual perch use.

Adult Home Range Searched[1]	Time (hrs:min)		Perches	
	Searching	Radio-tracking	No.[2]	Frequency[2]
Munger Mountain (RMS 31-33)	102:49	69:37	18 (12)	3 (5)
Butler Creek (RMS 34-36.5)	162:17	161:33	21 (0)	2
Gills (RMS 36.5-37)	43:31	36:52	22 (3)	2 (2)
Ford's (RMS 38-42)	238:23	55:26	16 (19)	2 (27)
Gros Ventre (RMS 43-50)	44:06	41:52	13 (0)	3

[1] RMS = River Mile Segments of Snake River.

[2] nonradio-tagged juveniles and immatures in parentheses.

Table 57. Summary of Management Zone recommendations for bald eagle breeding areas in the Greater Yellowstone Ecosystem (GYEBEWT 1983).

Zone I	Zone II	Zone III
Minimum human activity levels during nesting; light levels during other periods.	Light levels during nesting; moderate levels should not be exceeded during other periods.	Moderate human activity levels.
Habitat alterations only for the maintenance or enhancement of eagle nesting habitat.	Habitat alterations insure that nesting and foraging habitats are not degraded.	All projects affecting area should insure that the quality and availability of prey base is not degraded; and that important components of terrestrial habitat are maintained.
Same as Zone II.	No developments that may increase human activity level.	Developments that increase human activity levels designed to prevent impacts on Zones I and II.
Same as Zone III.	Same as Zone III.	No permanent development suitable for human occupancy.
Same as Zone II.	Utility lines should not be constructed in zone.	Utility lines should be limited to locations where the potential for eagle mortality is minimal.

[a]See GYEBEWT (1983) for definitions of terms used.

Table 58. Percent of total use areas classified high and medium use occurring in Management Zone II of bald eagle home ranges in the Greater Yellowstone Ecosystem.

	Use Area Classification	
Eagle(s) Monitored	High	Medium
Sheep Gulch Male	12.9	37.2
Elbow Pair[1]	89.6	-[a]
Dog Creek Pair	74.1	30
Cabin Creek Male	43.7	36.0
Hoback Pair	58.8	0
Butler Creek Female	72.7	100
Schwabacher Male	58.6	0
Oxbow Female	-[a]	48.5
Oxbow Male	89.5	89.5
Third Creek Female	0	31
Third Creek Male	45.4	0
Wilcox Point Male	96.7	12

[1] Observation time considerably less than other eagles/pairs.

[a] No such areas classified.

Table 59. Percent of total areas considered high and medium use in bald eagle home ranges which occurred within Management Zone III.

Eagle(s) Monitored	Use Area Classification	
	High	Medium
Sheep Gulch Male	11.3	51
Elbow Pair [1]	100	-[a]
Dog Creek Pair	100	100
Cabin Creek Male	93	84
Hoback Pair	100	51.3
Butler Creek Female	100	100
Schwabacher Male	100	22.6
Oxbow Female	-[a]	96.3
Oxbow Male	100	100
Third Creek Female	100	94.9
Third Creek Male	84	40.5
Wilcox Point Male	100	100

[1] Observation time considerably less than other eagles/pairs.

[a] No such areas classified.

FIGURES

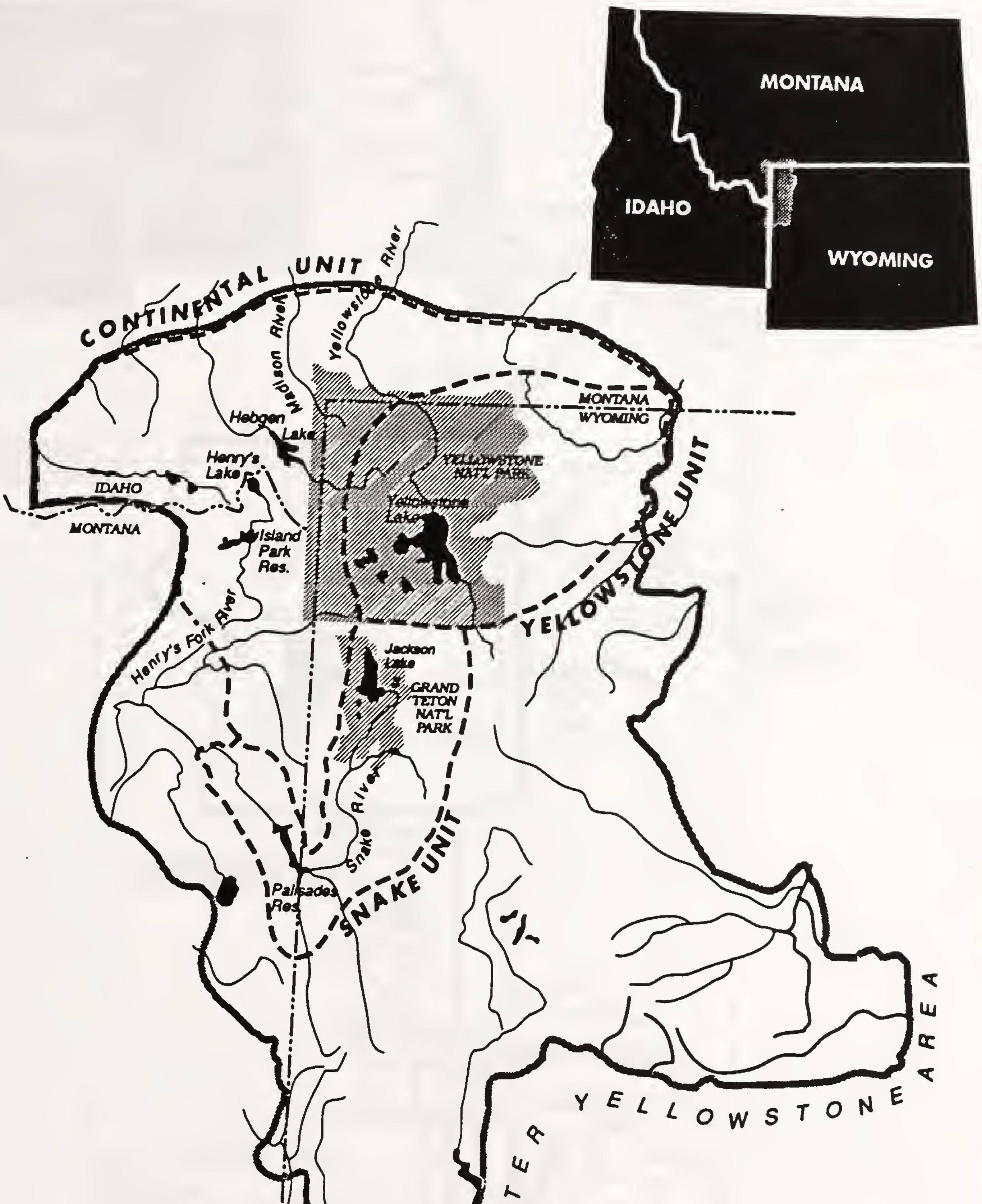

Figure 1. Bald eagle population units within the Greater Yellowstone Ecosystem.

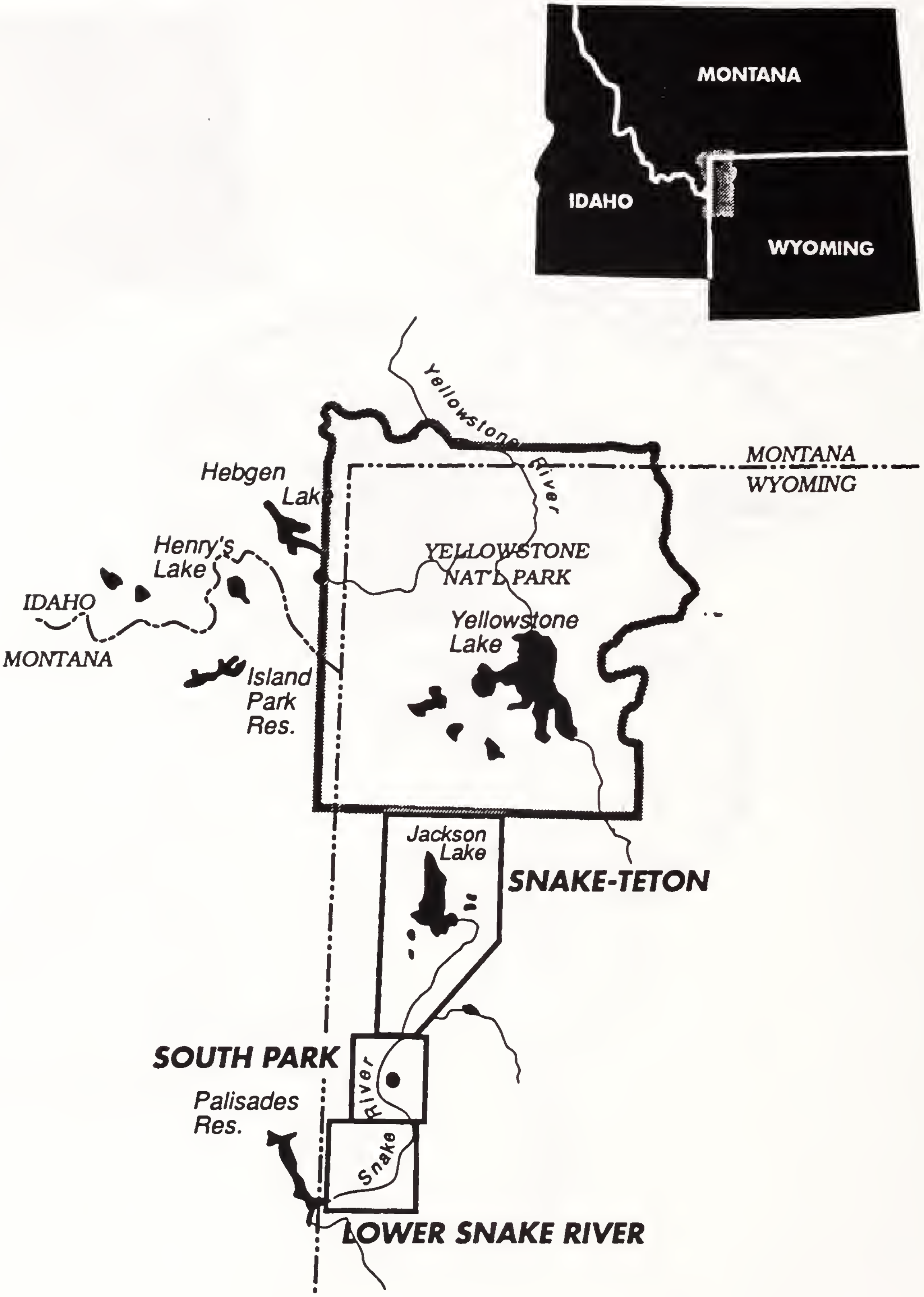

Figure 2. Bald eagle study areas within the Snake Wyoming portion of the Greater Yellowstone Ecosystem.

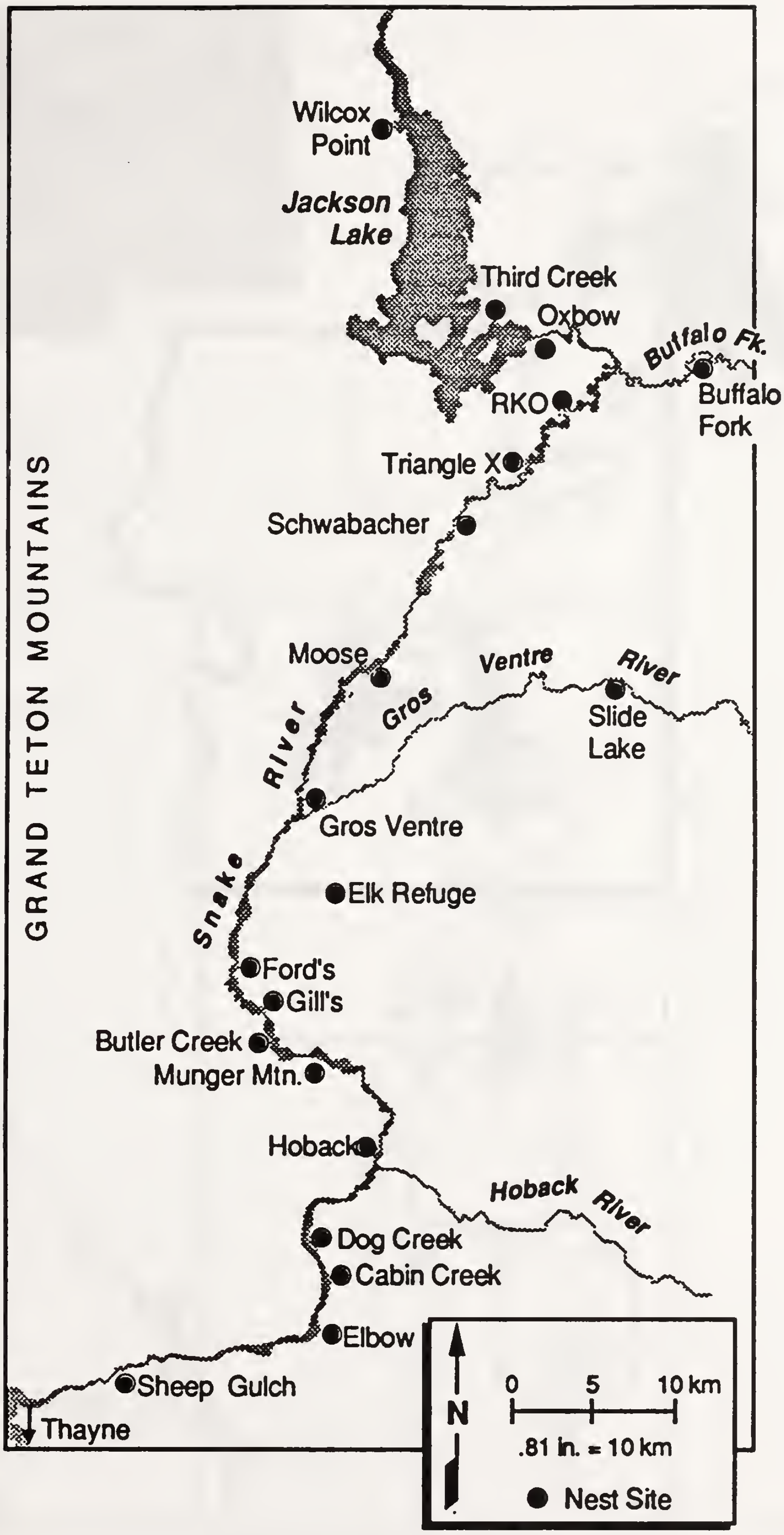

Figure 3. Bald eagle nest sites in the Snake Unit of Wyoming.

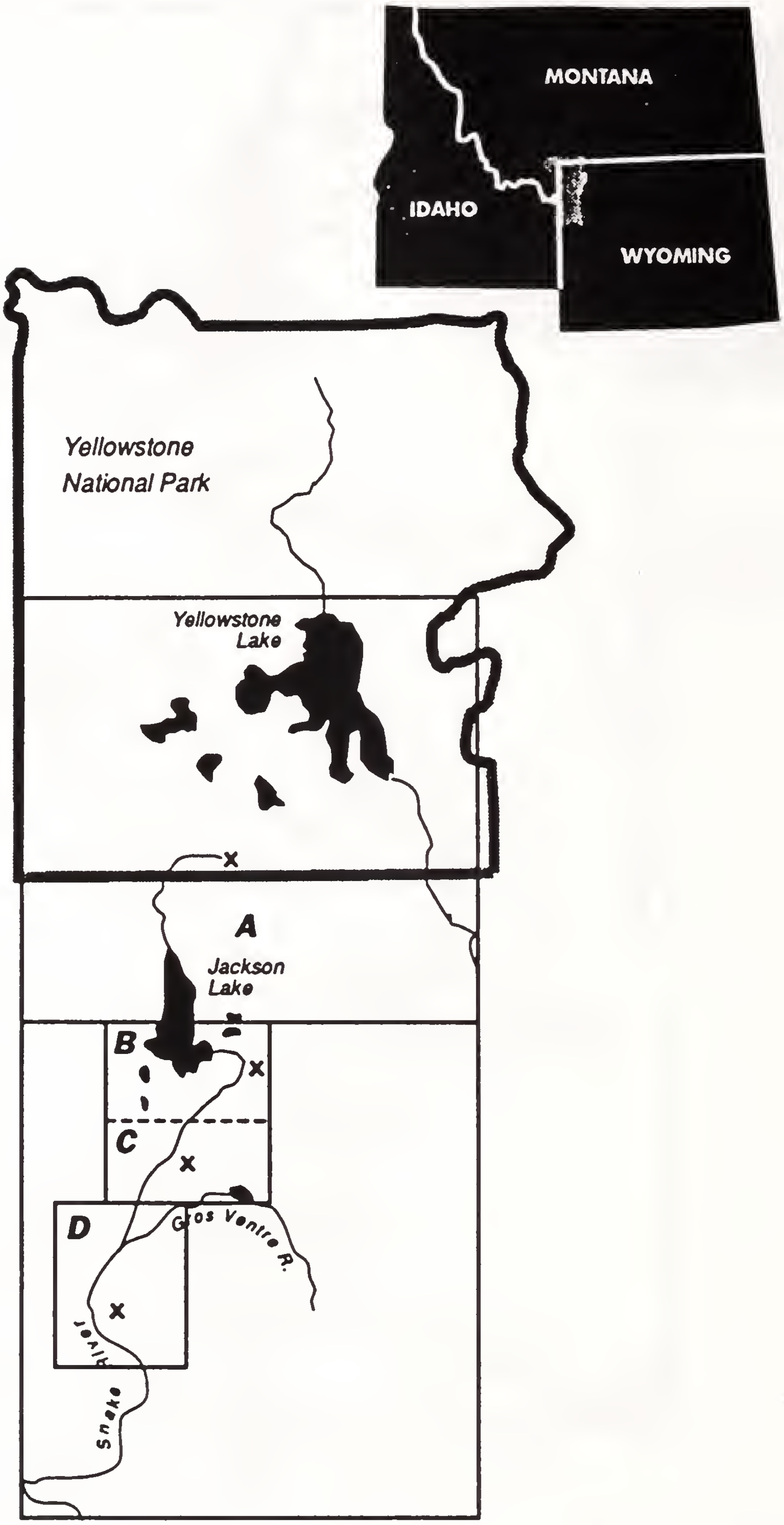

Figure 4. Weather recording stations and affected areas in the Snake Unit of Wyoming. Data from areas B and C were combined in analysis.

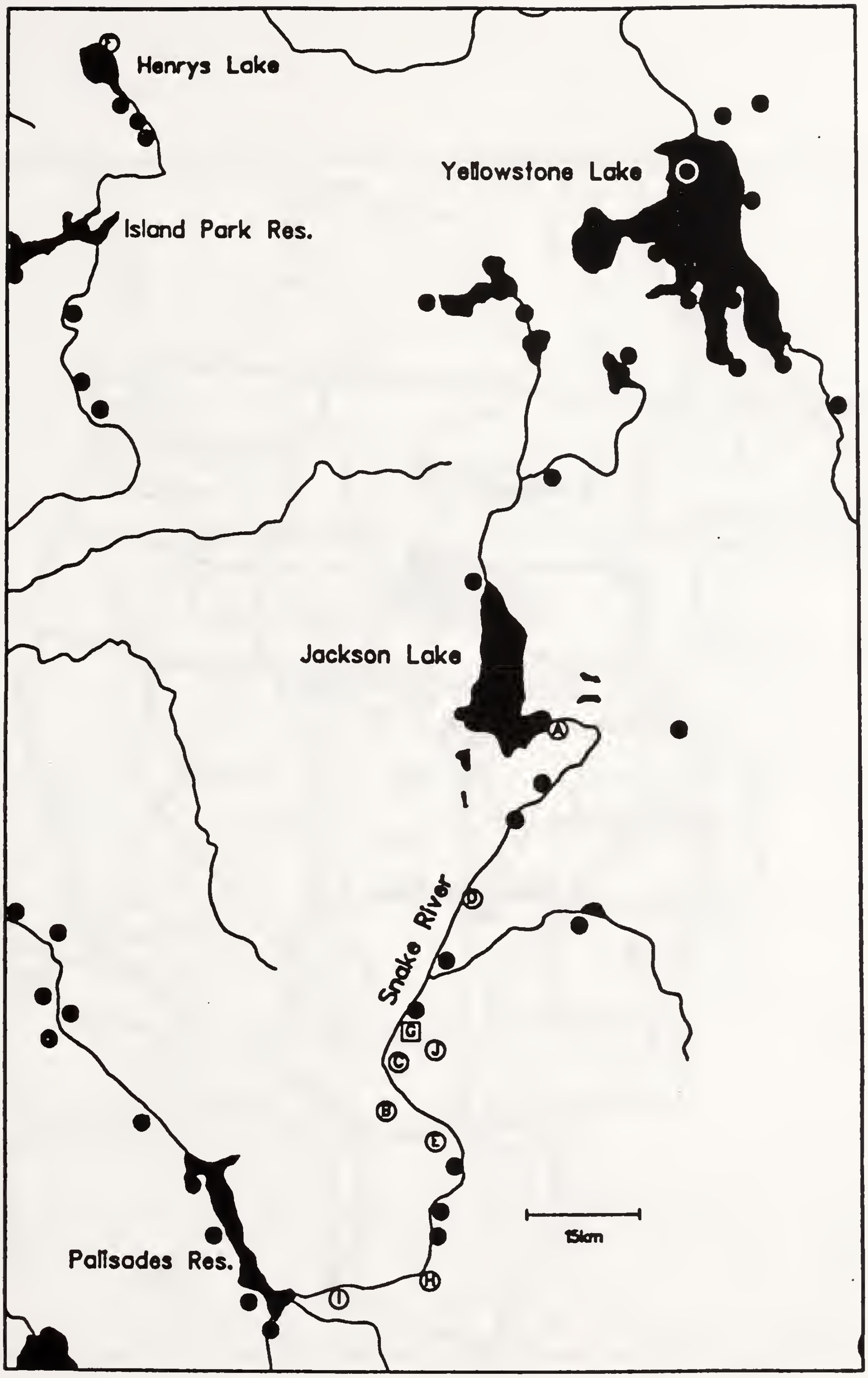

Figure 5. Bald eagle nest sites in the Greater Yellowstone Ecosystem where adults or nestlings exhibited unusual plumage coloration (open circles, A-F). Site G was natal nest of adults breeding at sites H and I. Dots indicate other bald eagle nest sites.

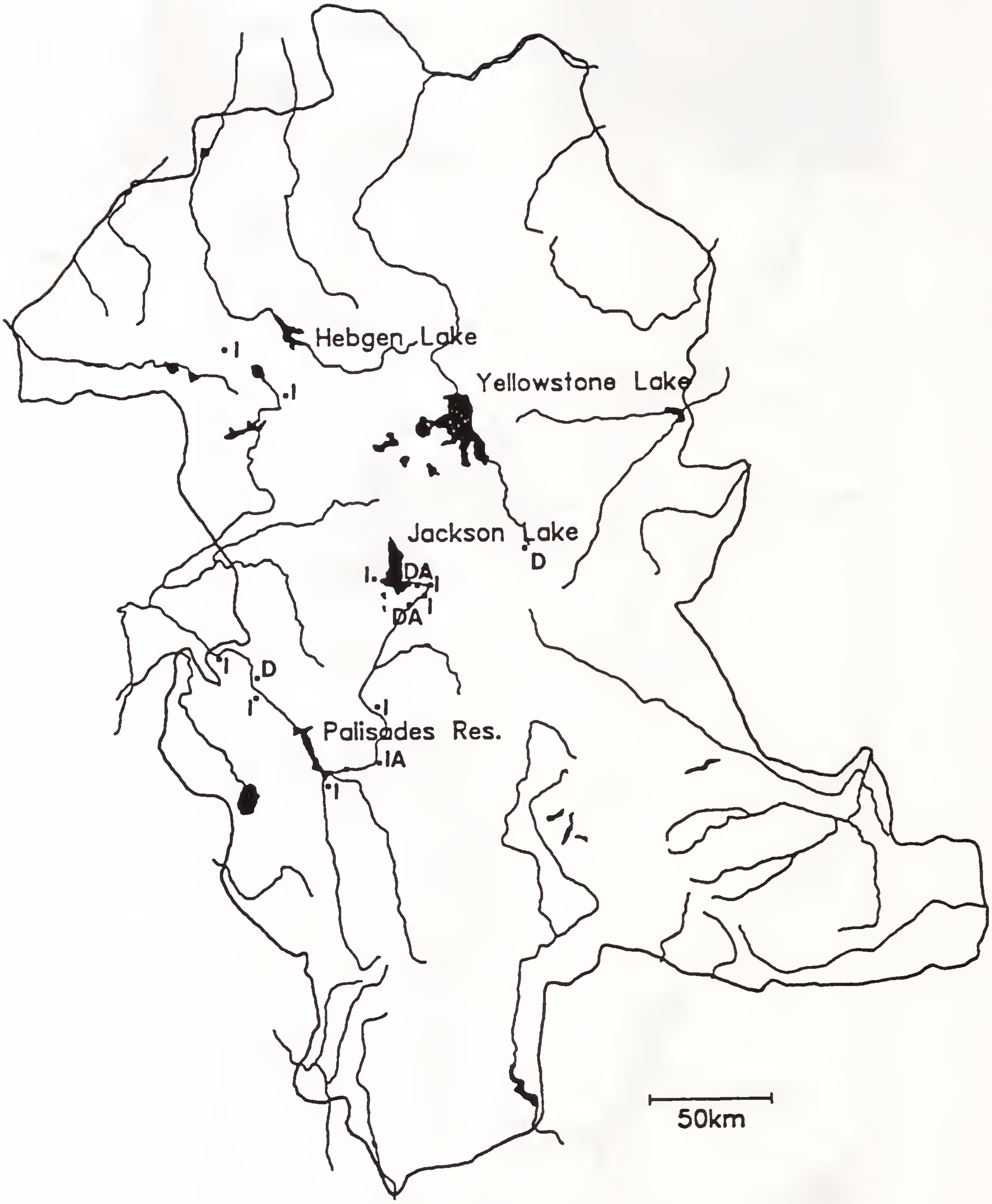

Figure 6. Encounters within the Greater Yellowstone Ecosystem of bald eagles banded in the Greater Yellowstone Ecosystem 1978-1990. D indicates direct encounter, I indicates indirect encounter. An A following D or I indicates eagle banded as an adult.

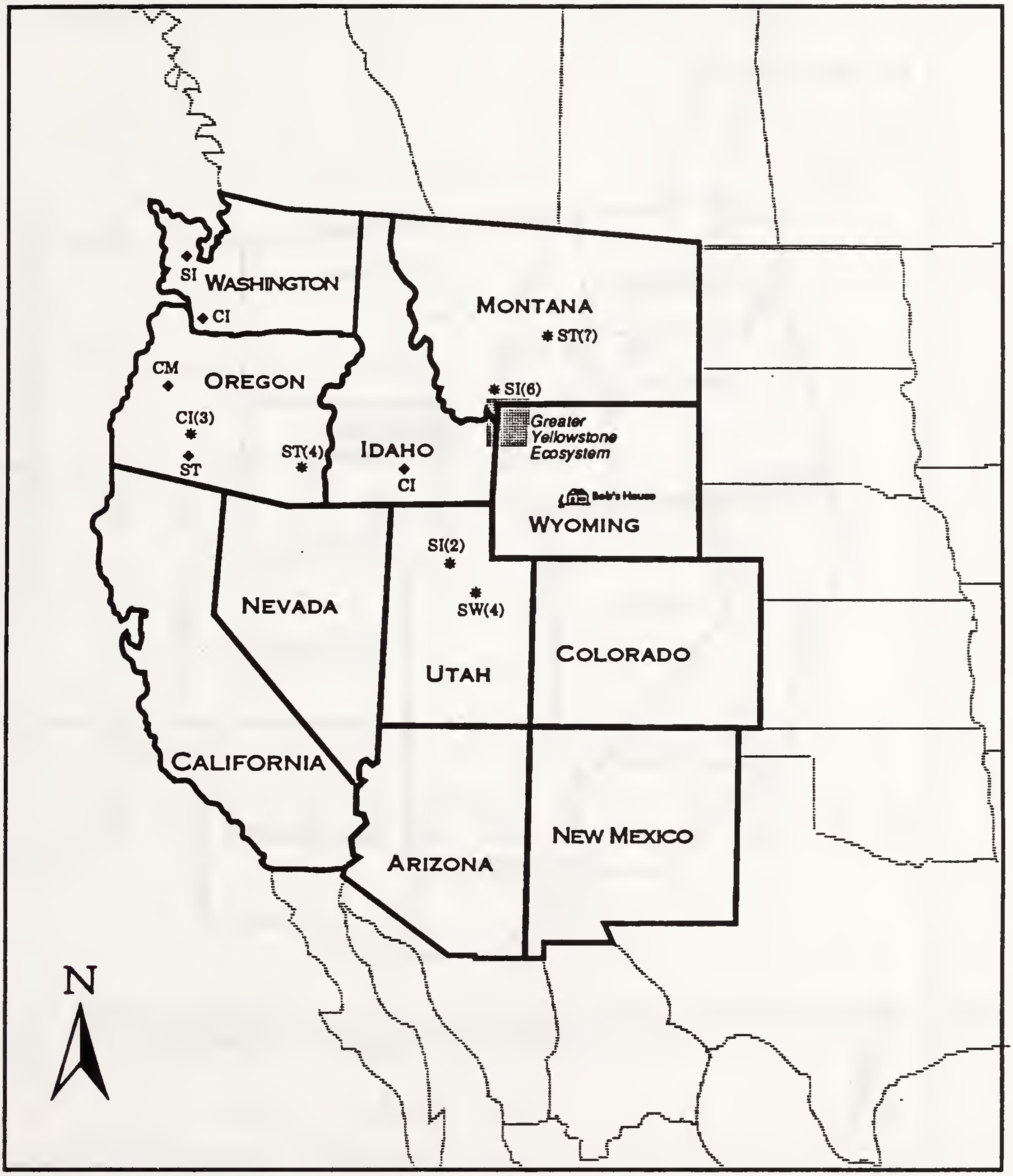

Figure 7. Extra-regional encounter locations of bald eagles banded in the Greater Yellowstone Ecosystem. Letters indicate Population Unit of origin within Greater Yellowstone Ecosystem. Diamonds indicate direct encounters, asterisks indicate indirect encounters. Numbers indicate age at encounter. ST(?) in Montana was of a migrant eagle banded as an adult.

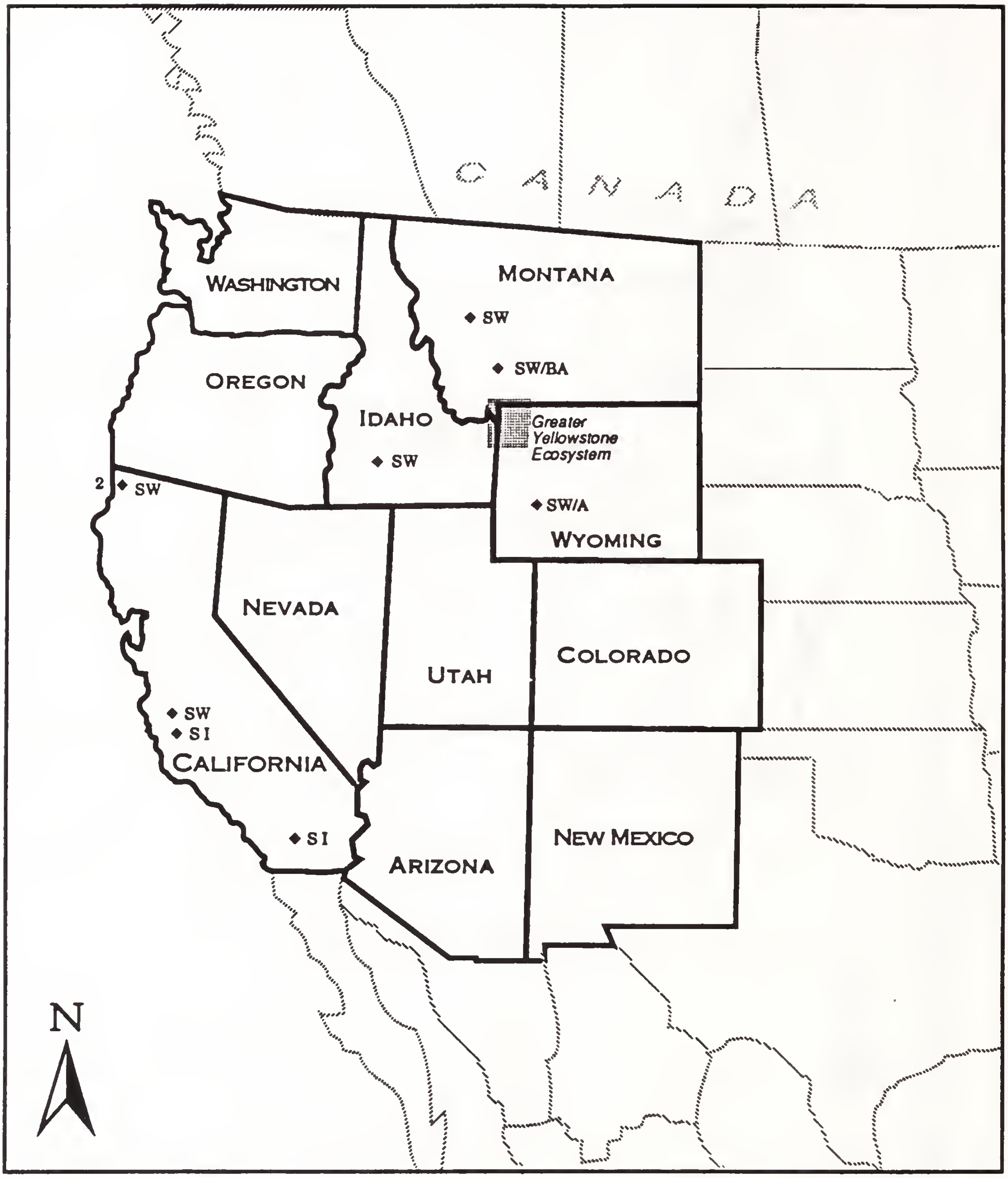

Figure 8. Extra-regional sightings of bald eagles colorbanded in the Greater Yellowstone Ecosystem. Letters indicate Population Unit of origin: SW = Snake Wyoming, SI = Snake Idaho. /BA = breeding adult, /A = adult.

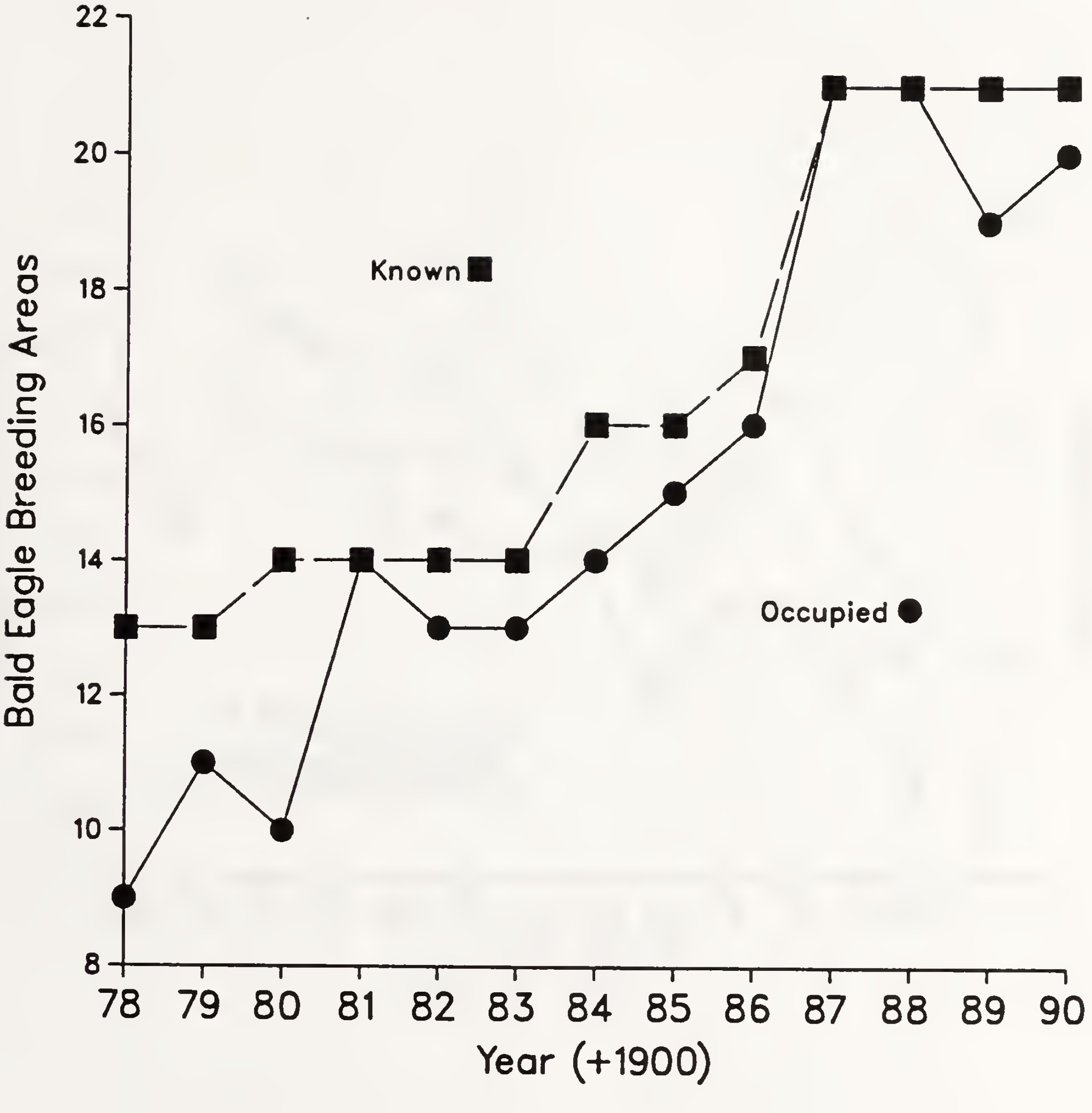

Figure 9. Number of known vs. occupied bald eagle breeding areas in the Snake Unit of Wyoming, Greater Yellowstone Ecosystem, 1978-1990.

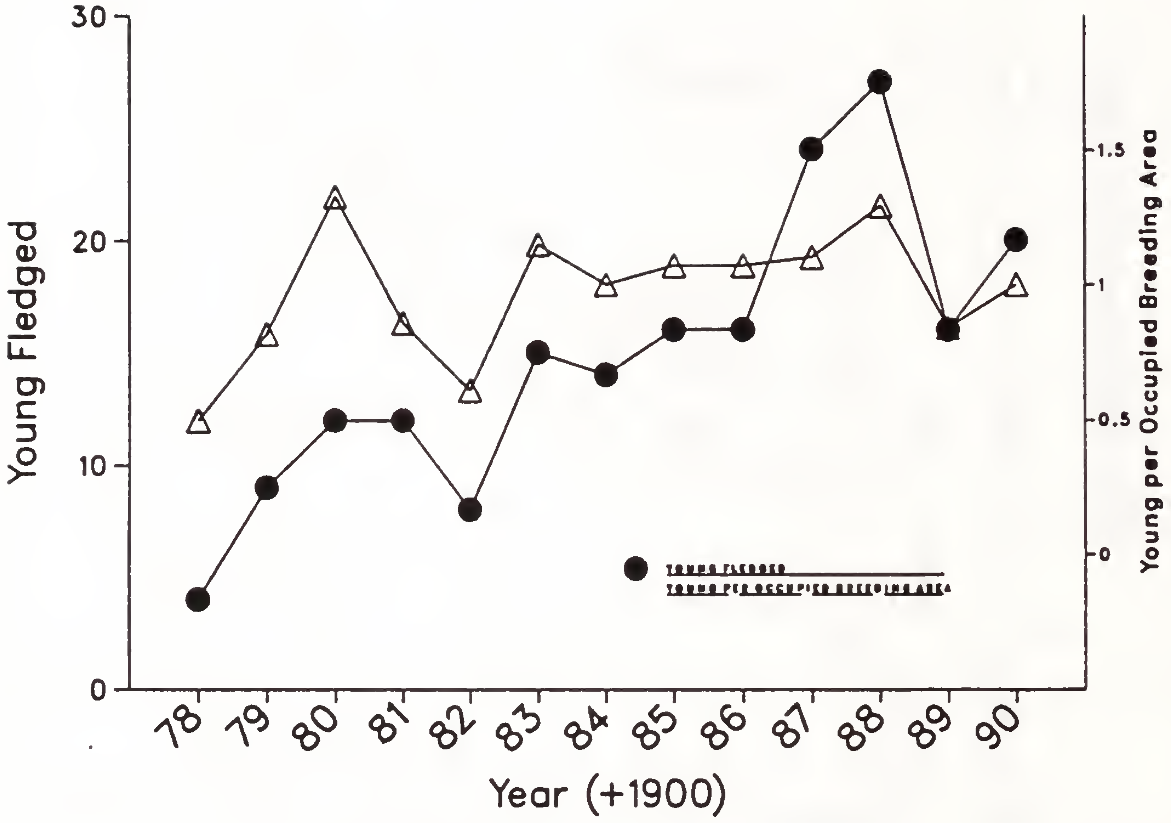

Figure 10. Total young bald eagles produced and young per occupied breeding area in the Snake Unit of Wyoming, Greater Yellowstone Ecosystem.

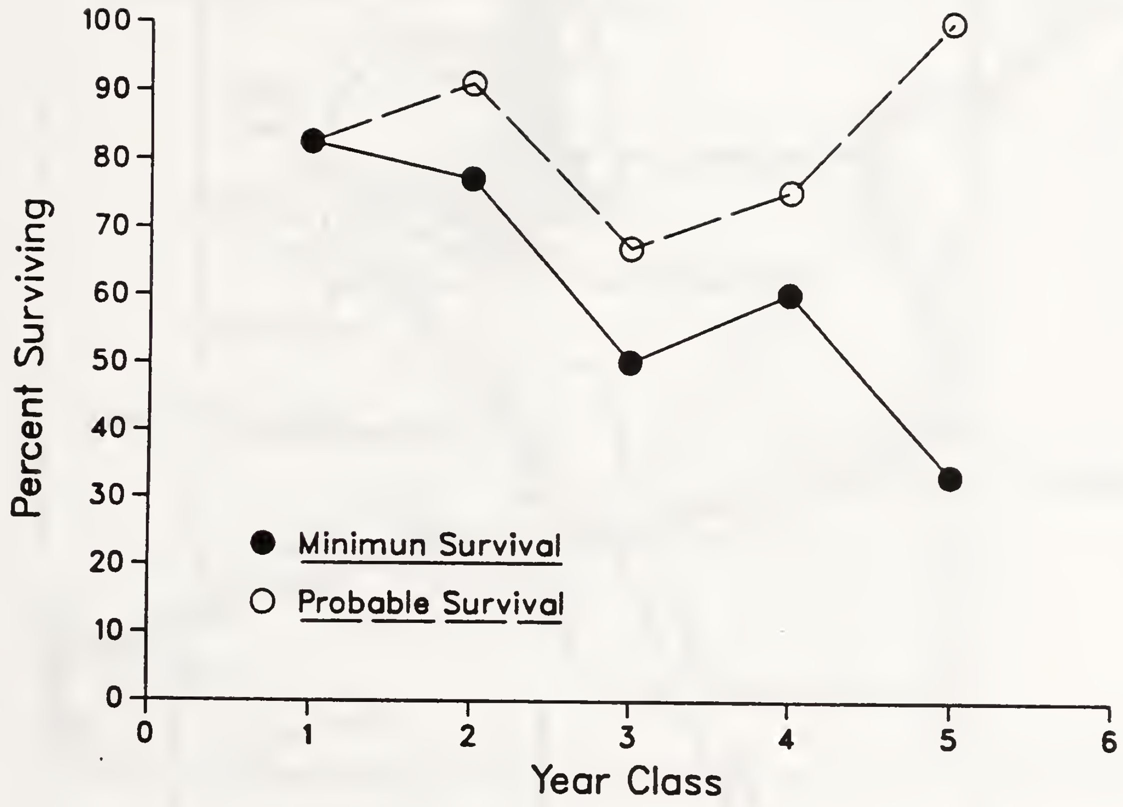

Figure 11. Survival of immature bald eagles as manifested in percent detected years after radio-tagging as nestlings or fledglings. Percent is calculated based on number alive (detected) the previous year, not of original cohort. Probable survival considers known and probable radio failures.

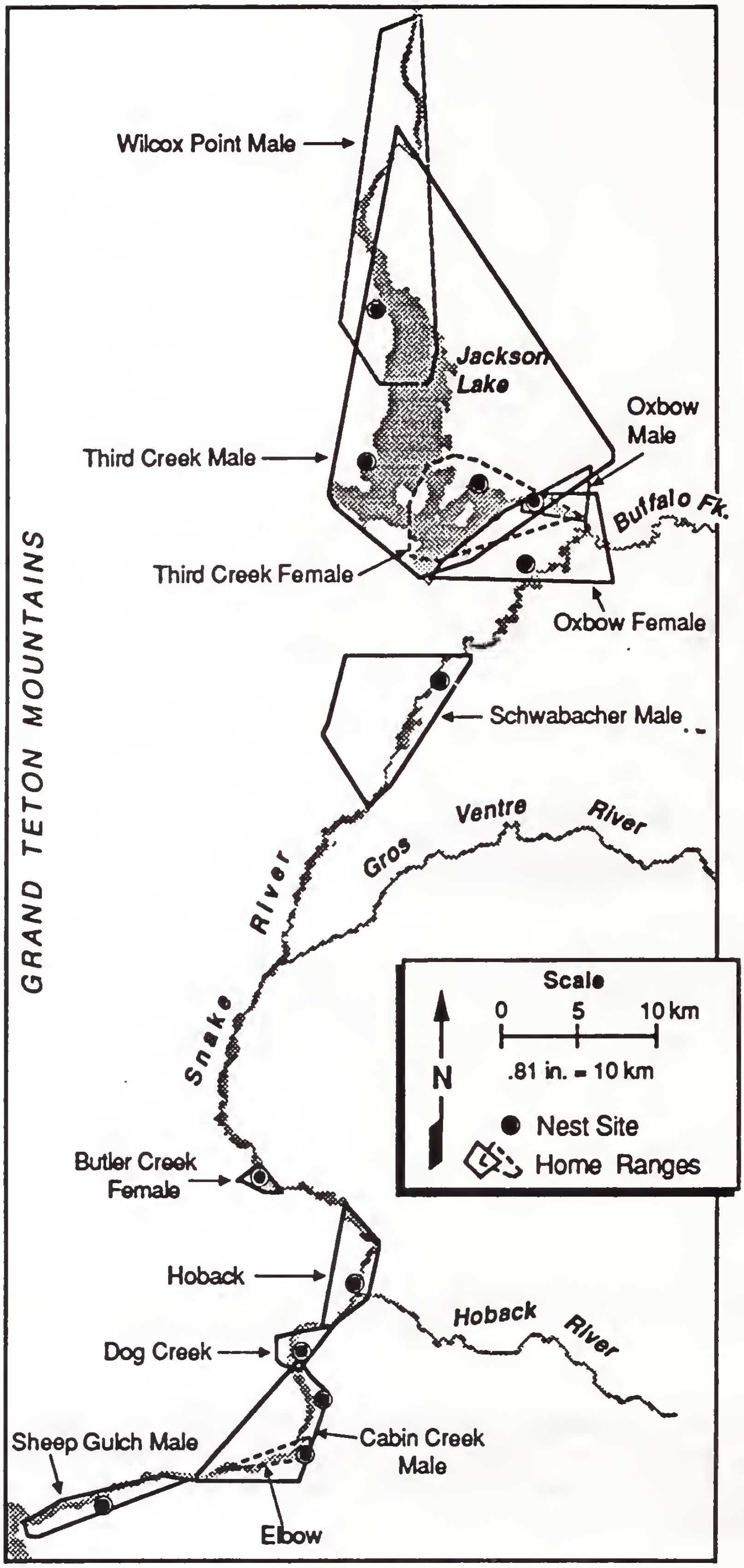

Figure 12. Home ranges of bald eagles determined by radio-tracking in the Snake Unit of Wyoming, Greater Yellowstone Ecosystem. Elbow, Dog Creek, and Hoback ranges were determined by visual tracking.

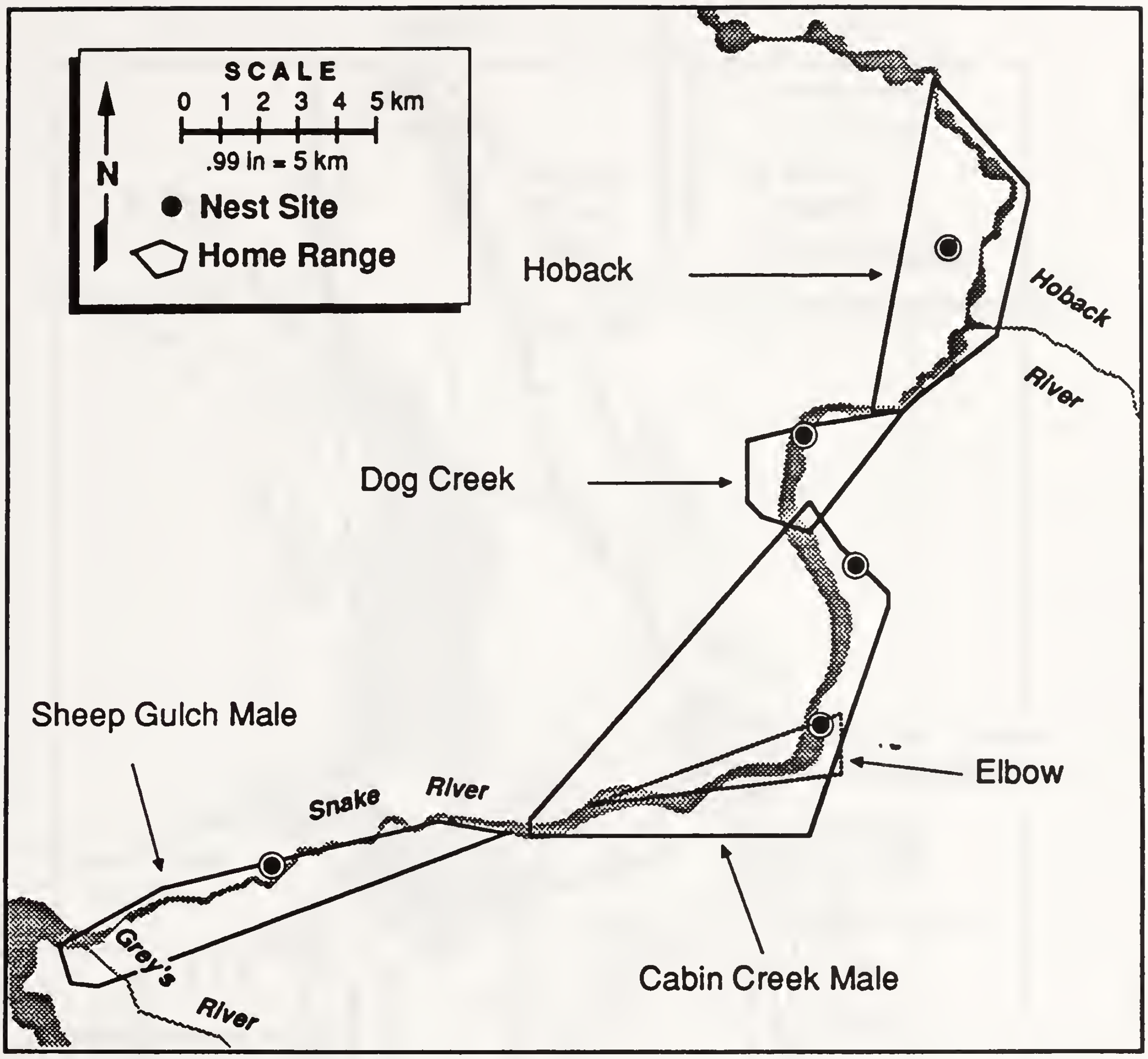

Figure 13. Home ranges of adult bald eagles monitored visually (Elbow, Dog Creek, Hoback) or by telemetry, 1985-1987 in the Lower Snake River of Wyoming, Greater Yellowstone Ecosystem.

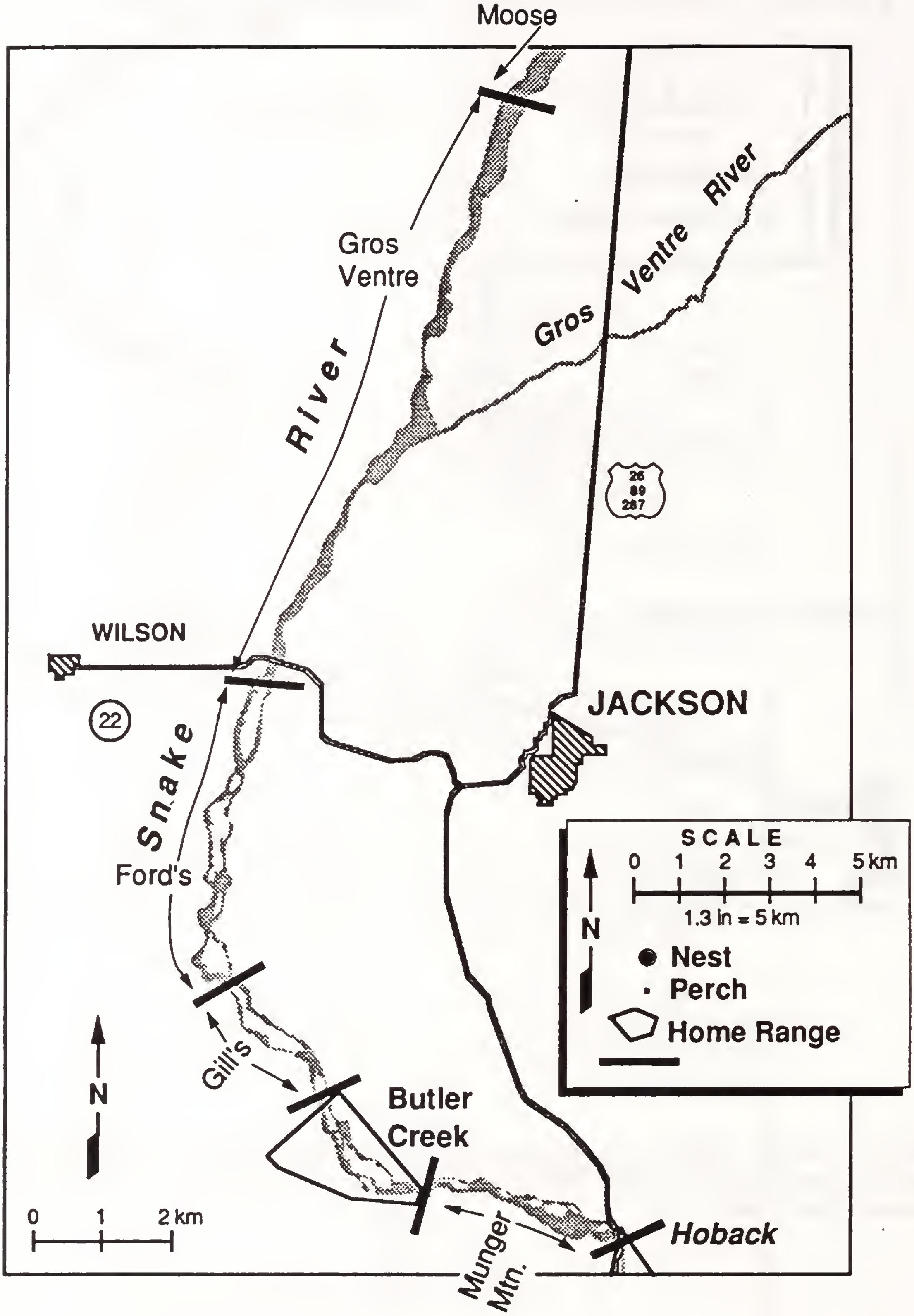

Figure 14. Home range of Butler Creek adult bald eagles determined by telemetry and visually, and range boundaries of other bald eagle pairs on the Snake River in South Park, Wyoming, 1987-1989.

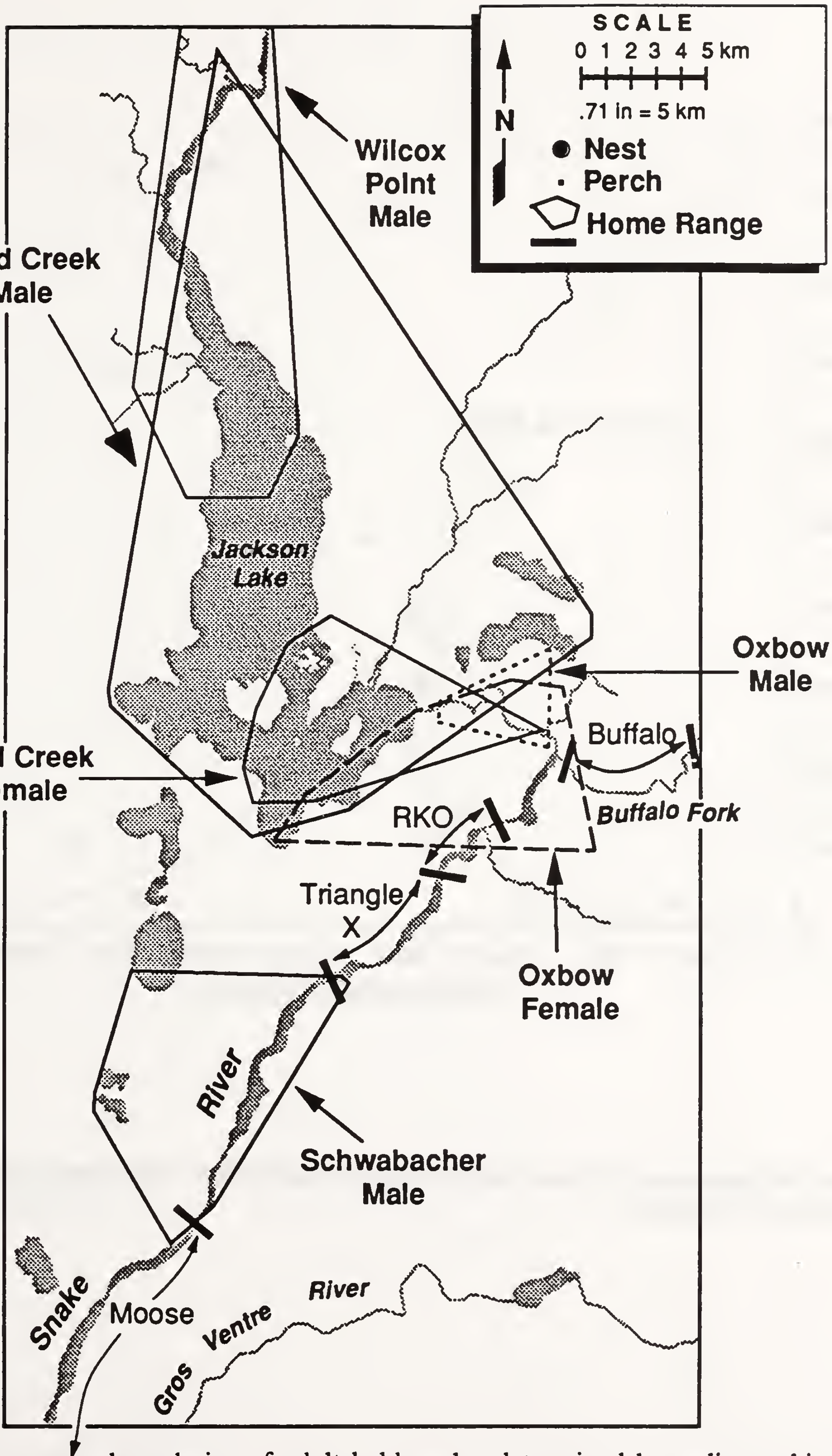

Figure 15. Home range boundaries of adult bald eagles determined by radio-tracking, and range boundaries of other bald eagle pairs determined visually on the Snake River in Snake Teton portion of Wyoming, 1988-1989.

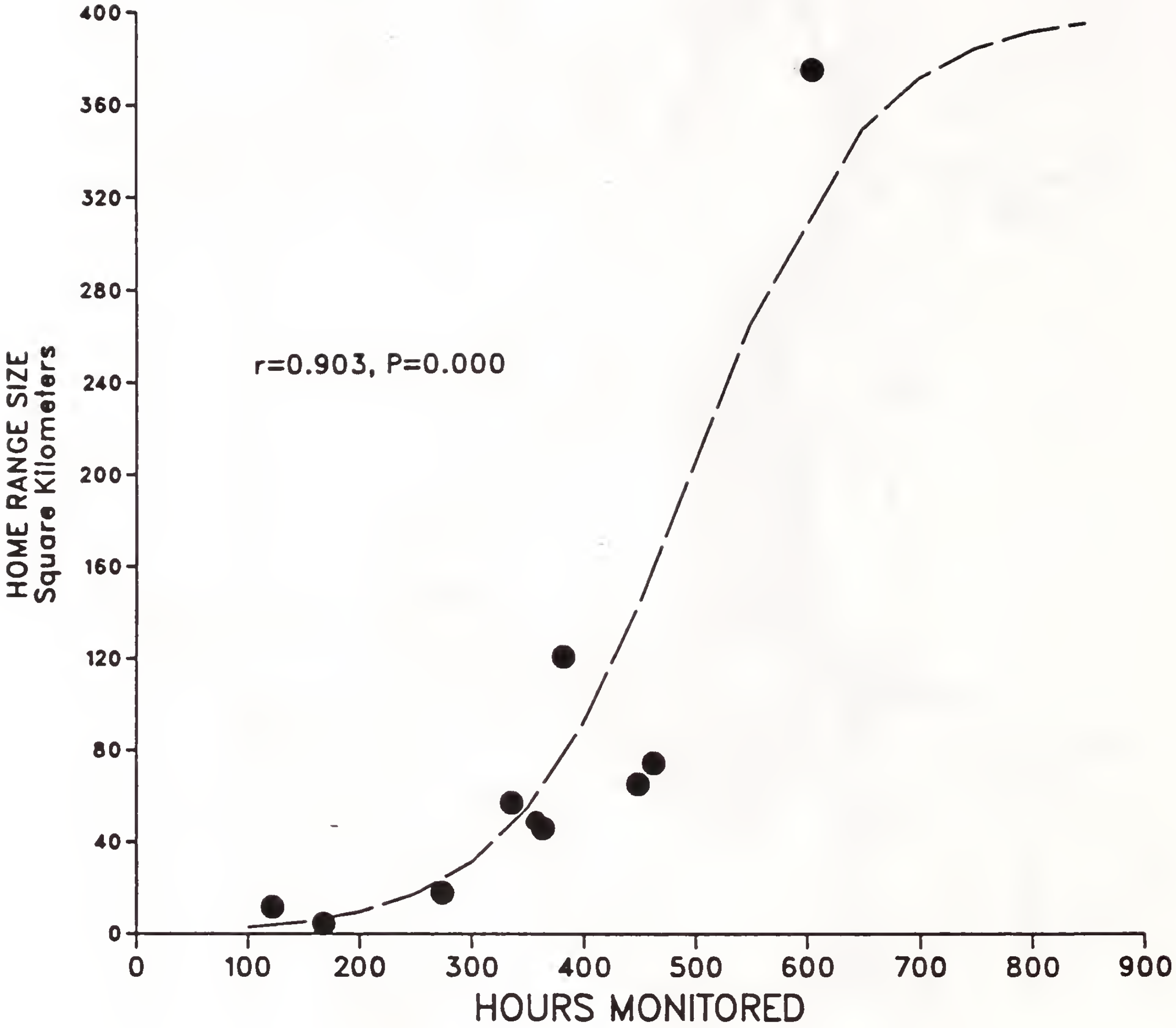

Figure 16. Regression of hours monitored and resultant bald eagle home range size detected (all bald eagles studied).

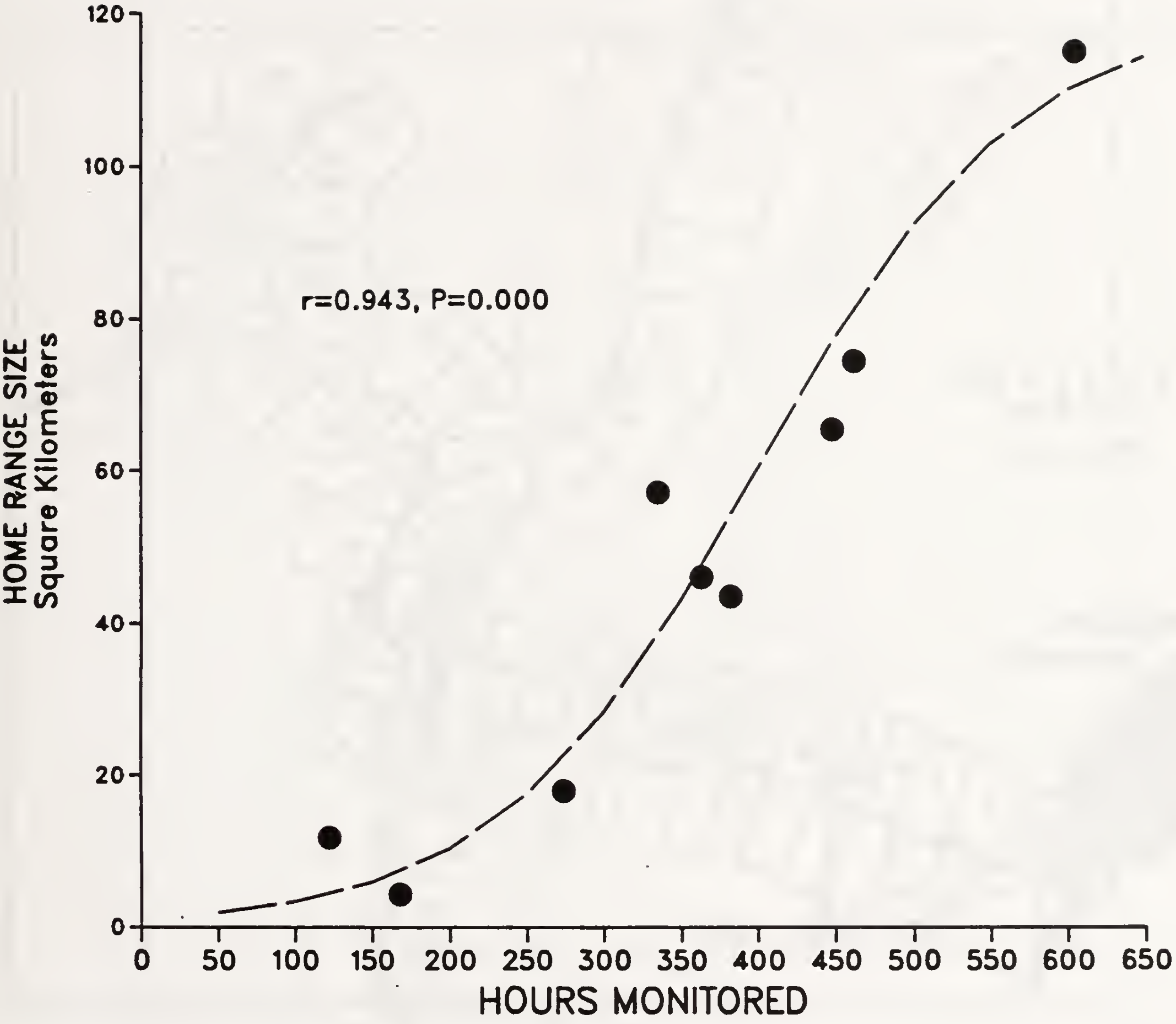

Figure 17. Regression of hours monitored and resultant bald eagle home range size detected (excluding Wilcox Point).

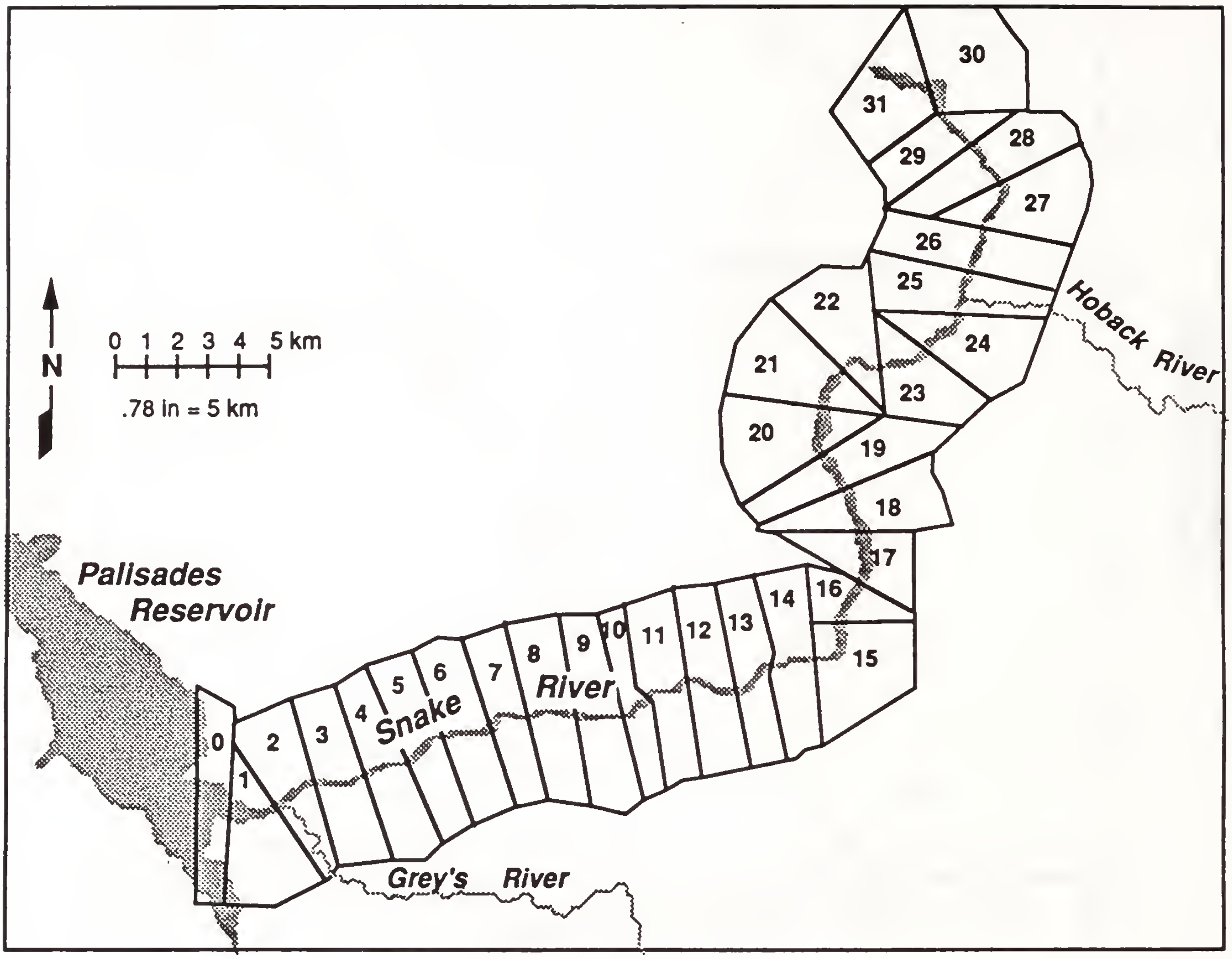

Figure 18. River Mile Segments designated along the Lower Snake River, Wyoming.

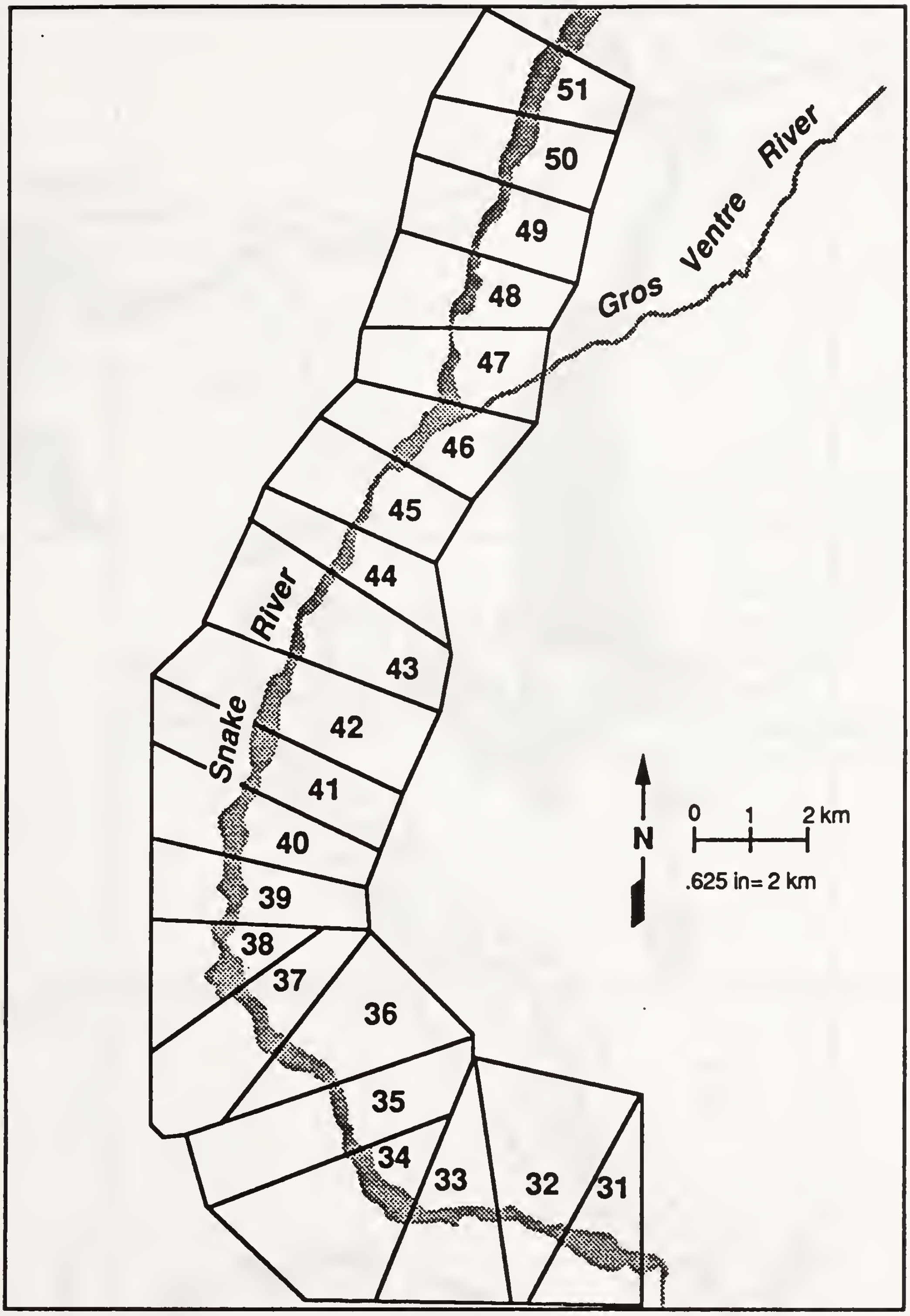

Figure 19: River Mile Segments designated along the Snake River in South Park, Wyoming.

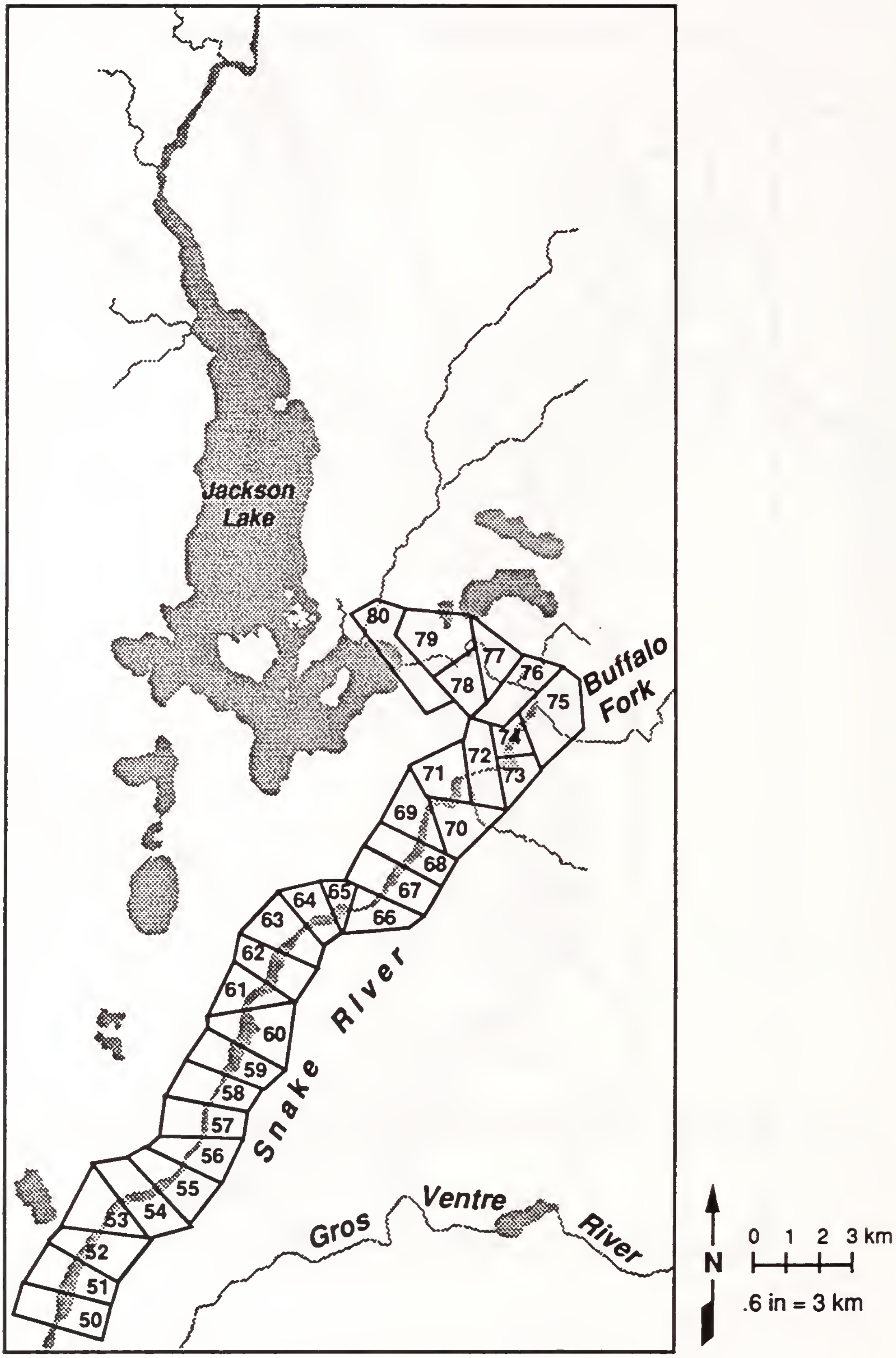

Figure 20. River Mile Segments designated along the Snake River in Snake Teton, Wyoming.

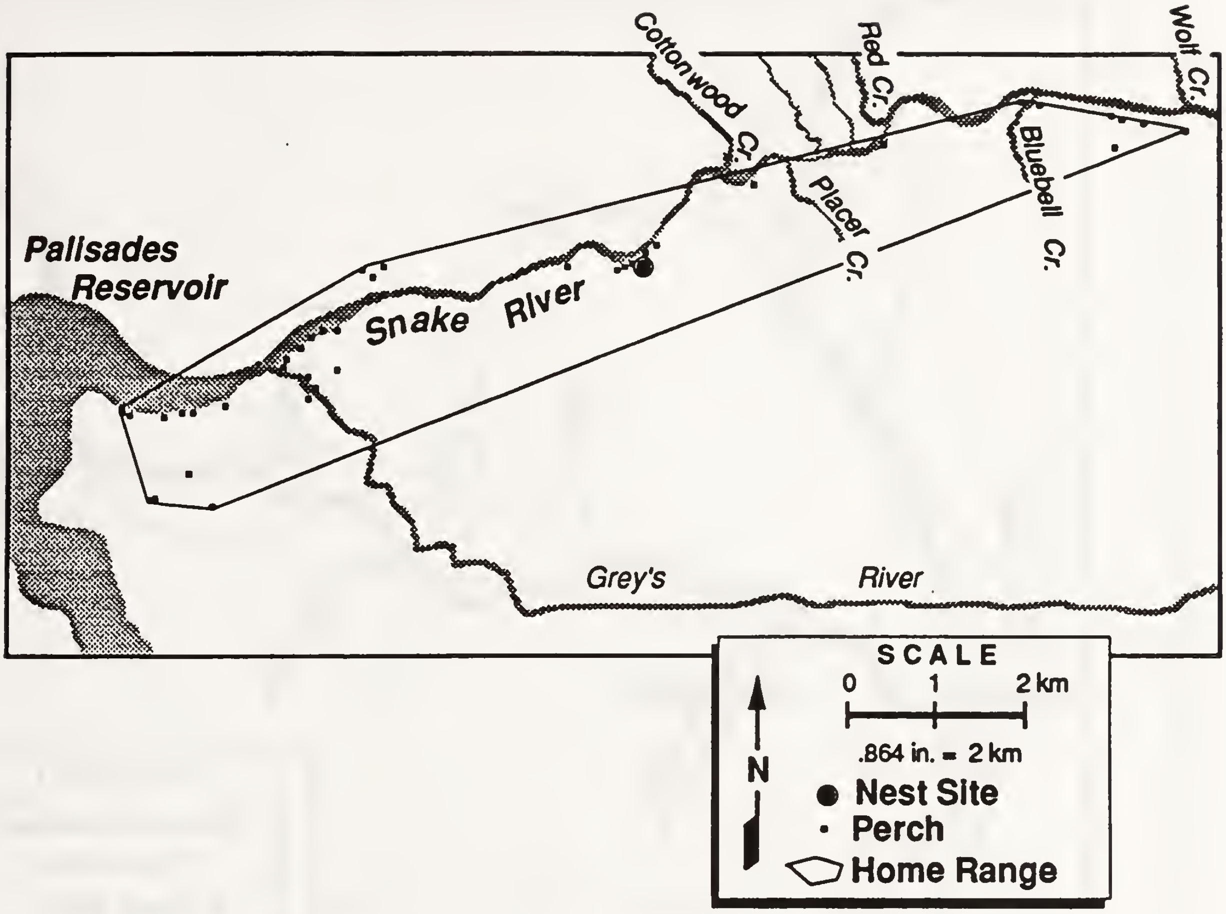

Figure 21. Home range and perch locations of the Sheep Gulch adult male bald eagle (radio-tagged), 1986.

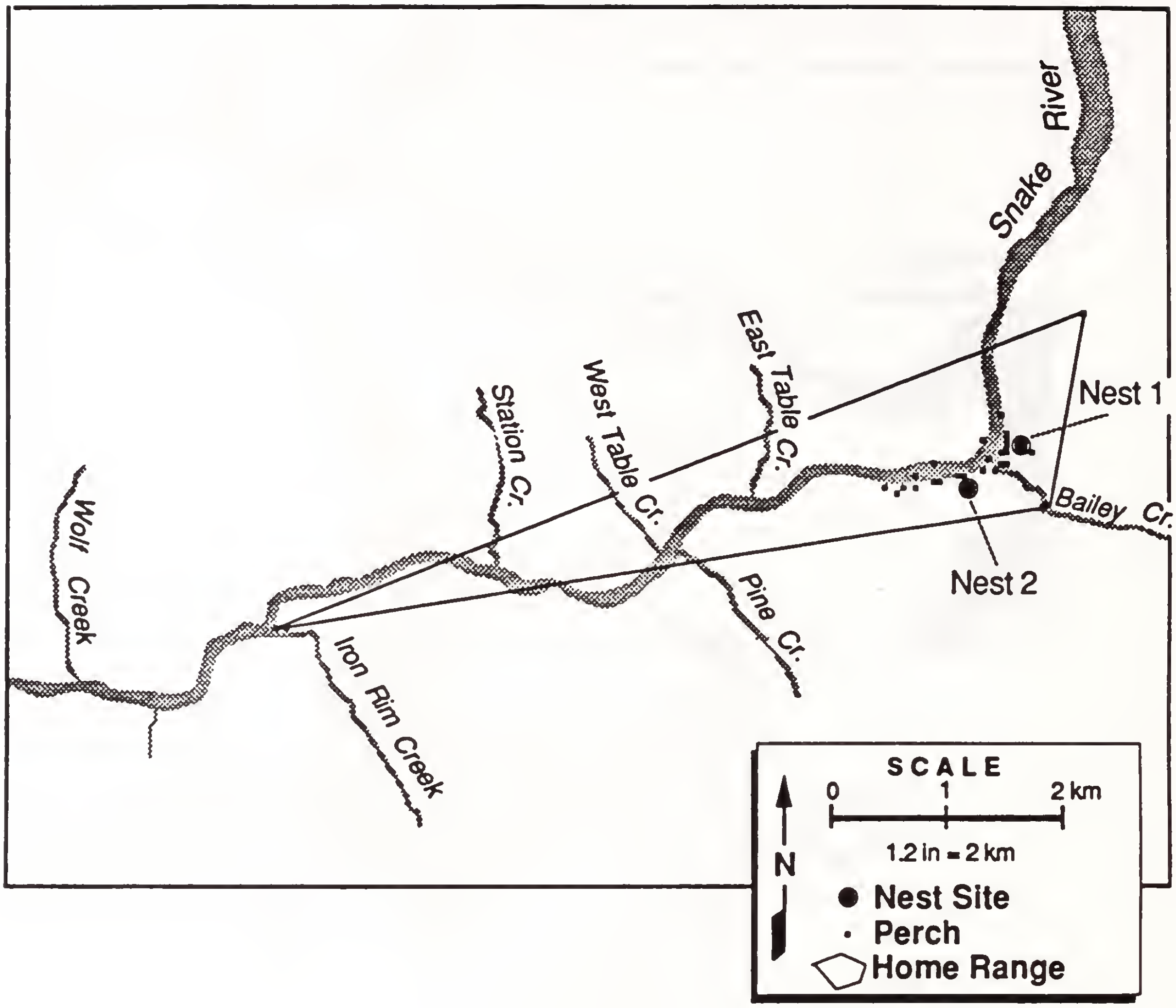

Figure 22. Home range and perch sites of adult bald eagles associated with the Elbow nest site in the Lower Snake River, Wyoming, 1987-1989.

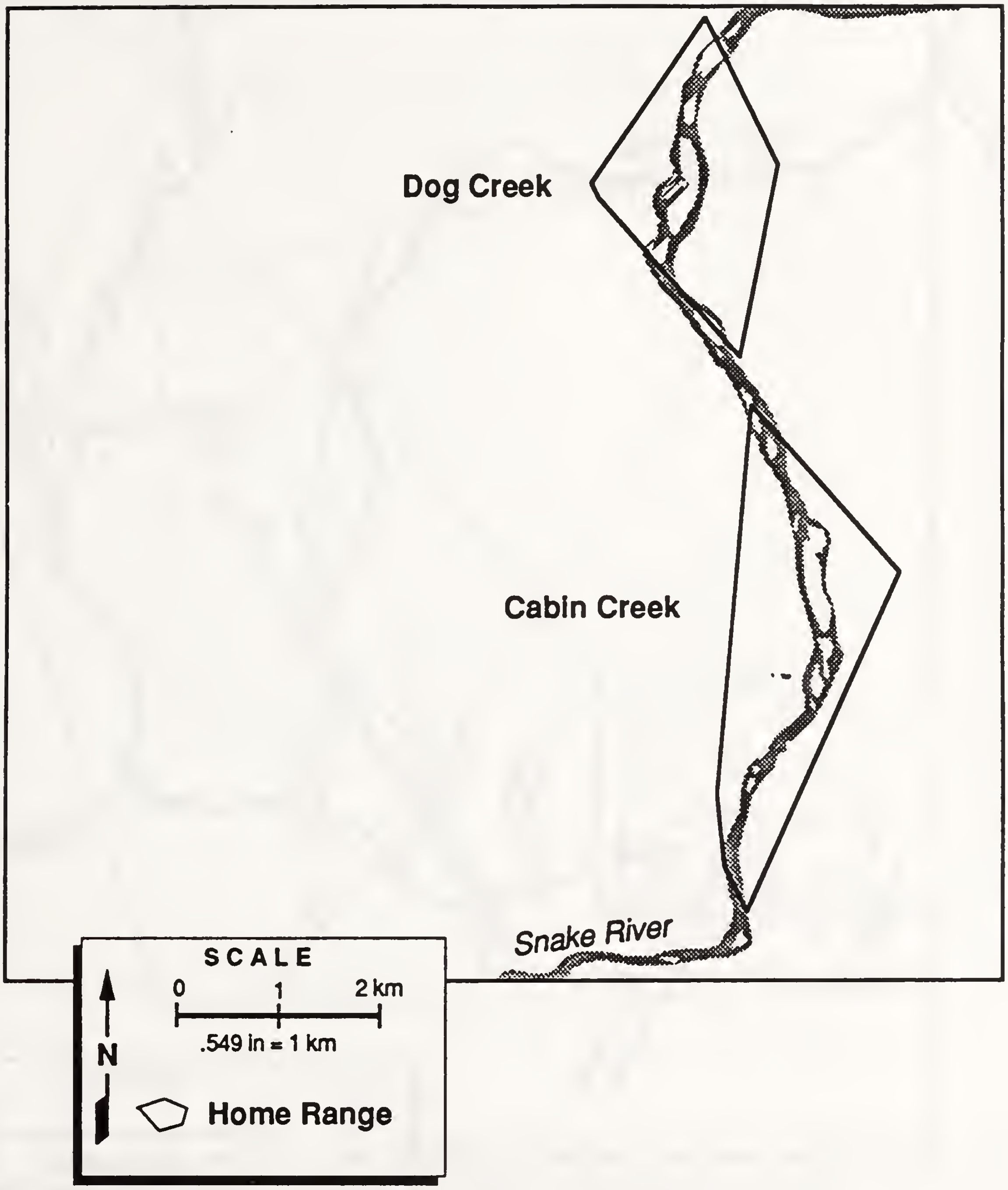

Figure 23. Home range of bald eagles associated with the Cabin Creek and Dog Creek nest sites in the Lower Snake River, Wyoming, 1978-1982, as determined visually.

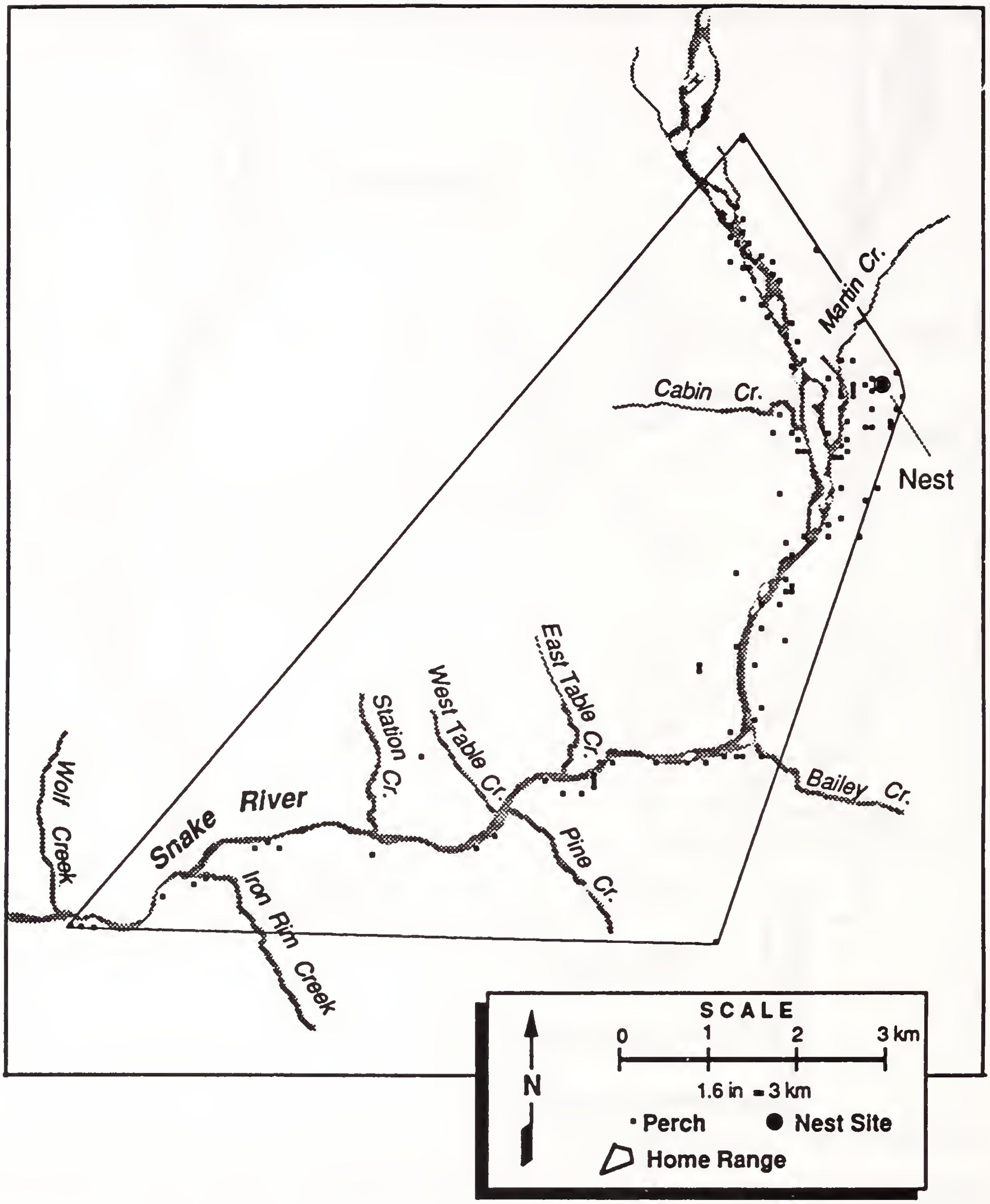

Figure 24. Home range and perch sites of Cabin Creek male bald eagle in the Lower Snake River, Wyoming, 1986, as determined by radio-tracking.

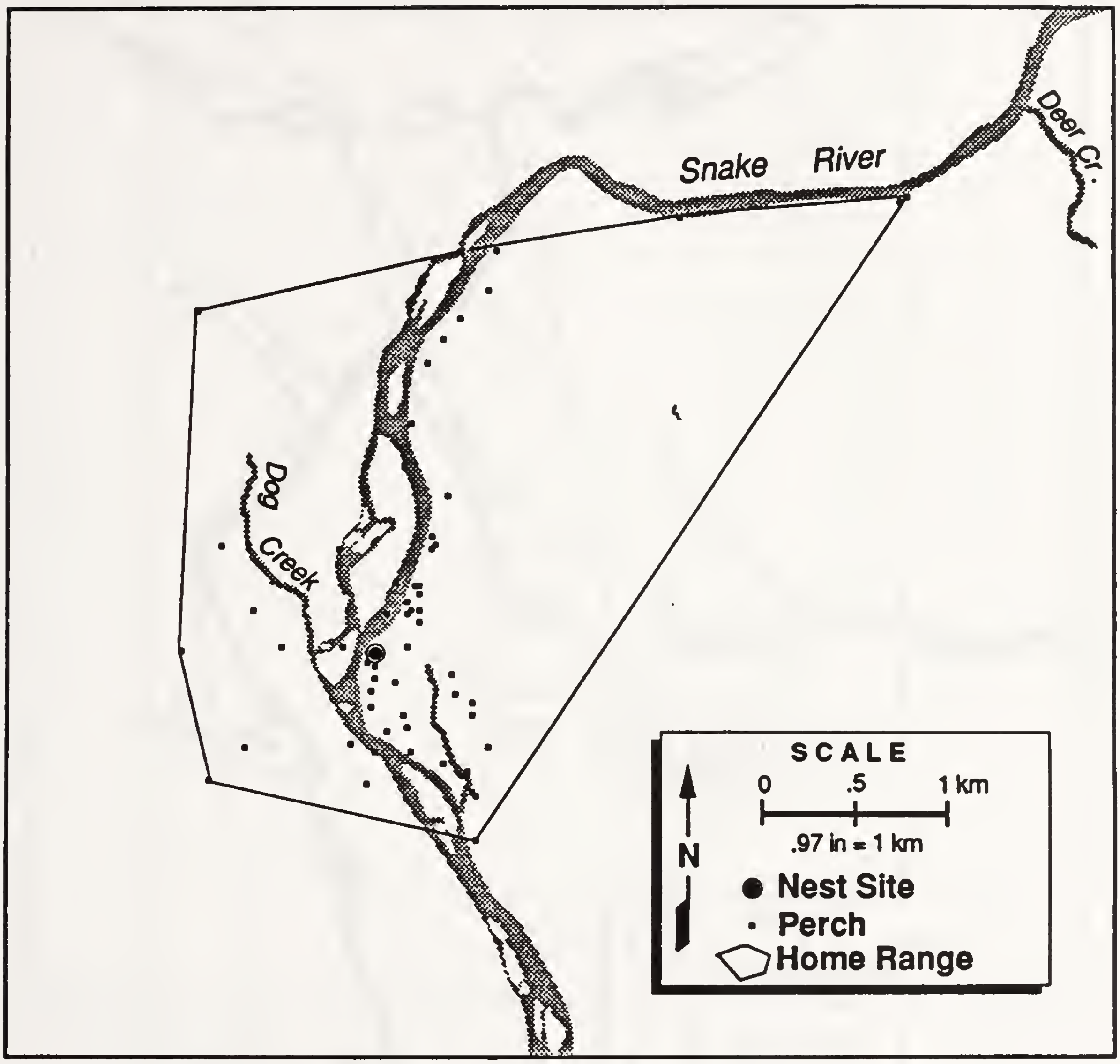

Figure 25. Home range and perch sites of adult bald eagles associated with the Dog Creek nest in the Lower Snake River, Wyoming, 1985-1989, as determined visually.

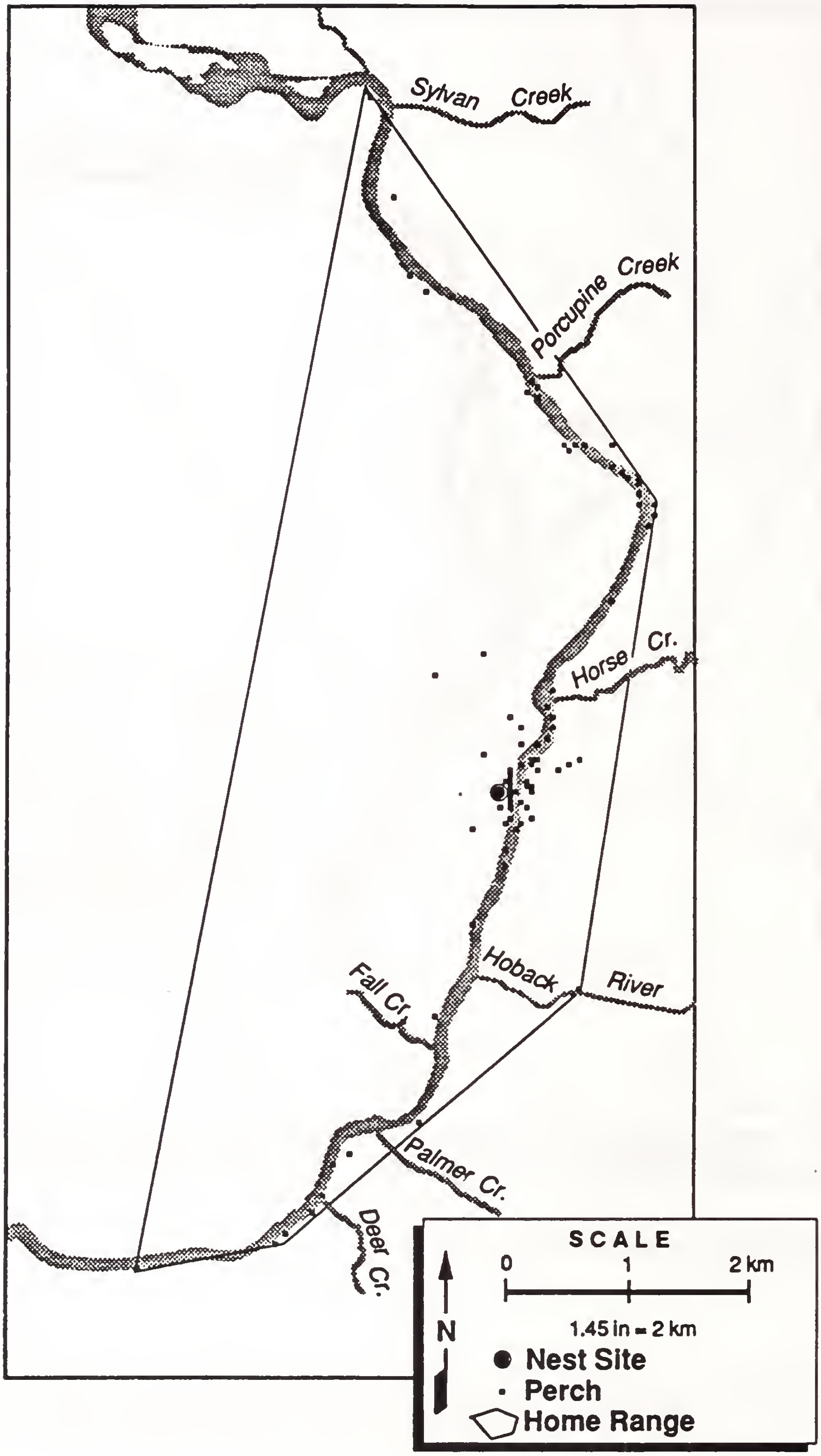

Figure 26. Home range and perch sites of adult bald eagles associated with the Hoback nest site in the Lower Snake River, Wyoming, 1985-1987, as determined visually.

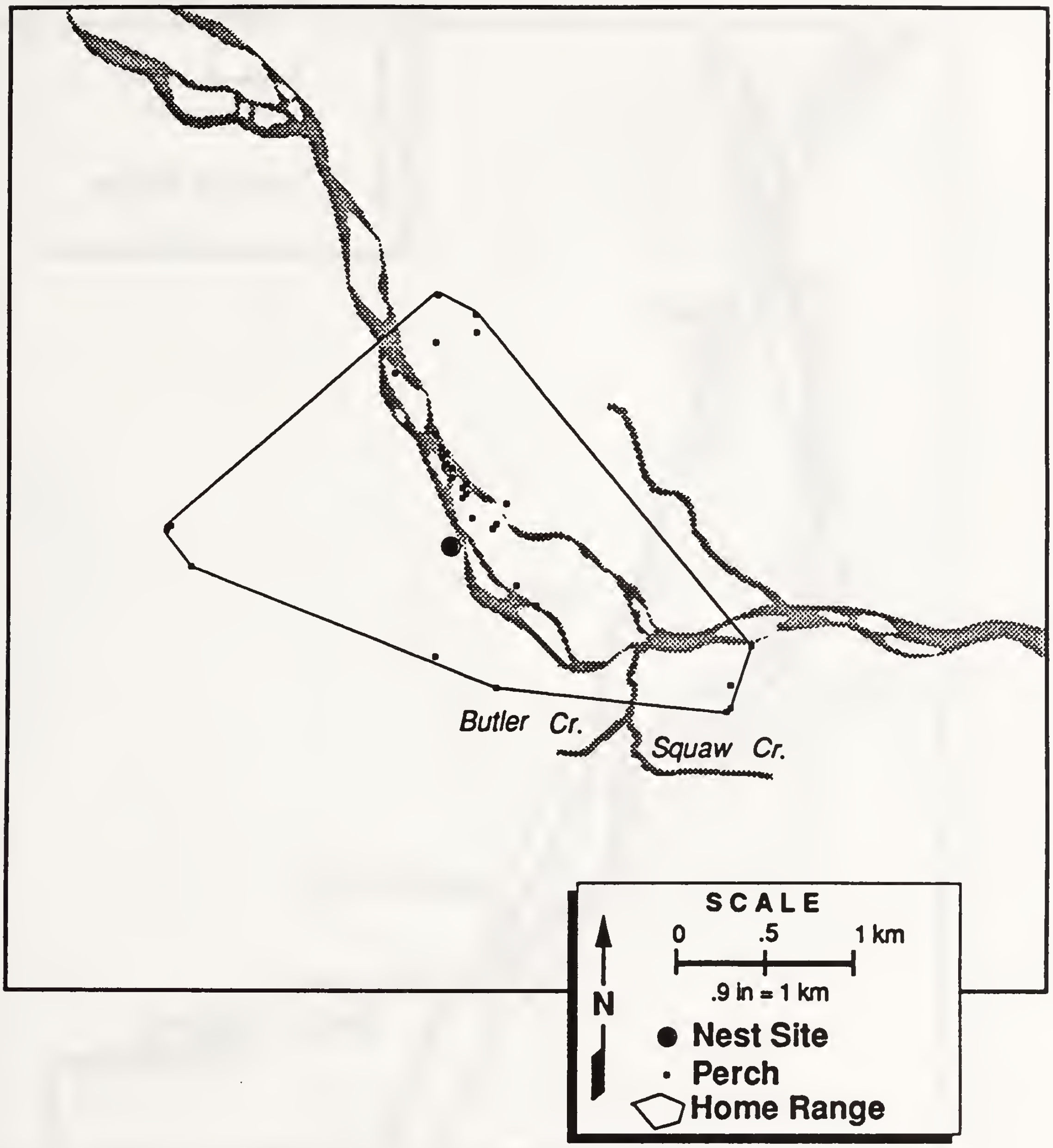

Figure 27. Home range and perch sites of adult bald eagles associated with the Butler Creek nest site in South Park, Wyoming, 1986, as determined visually (male) and by telemetry (female).

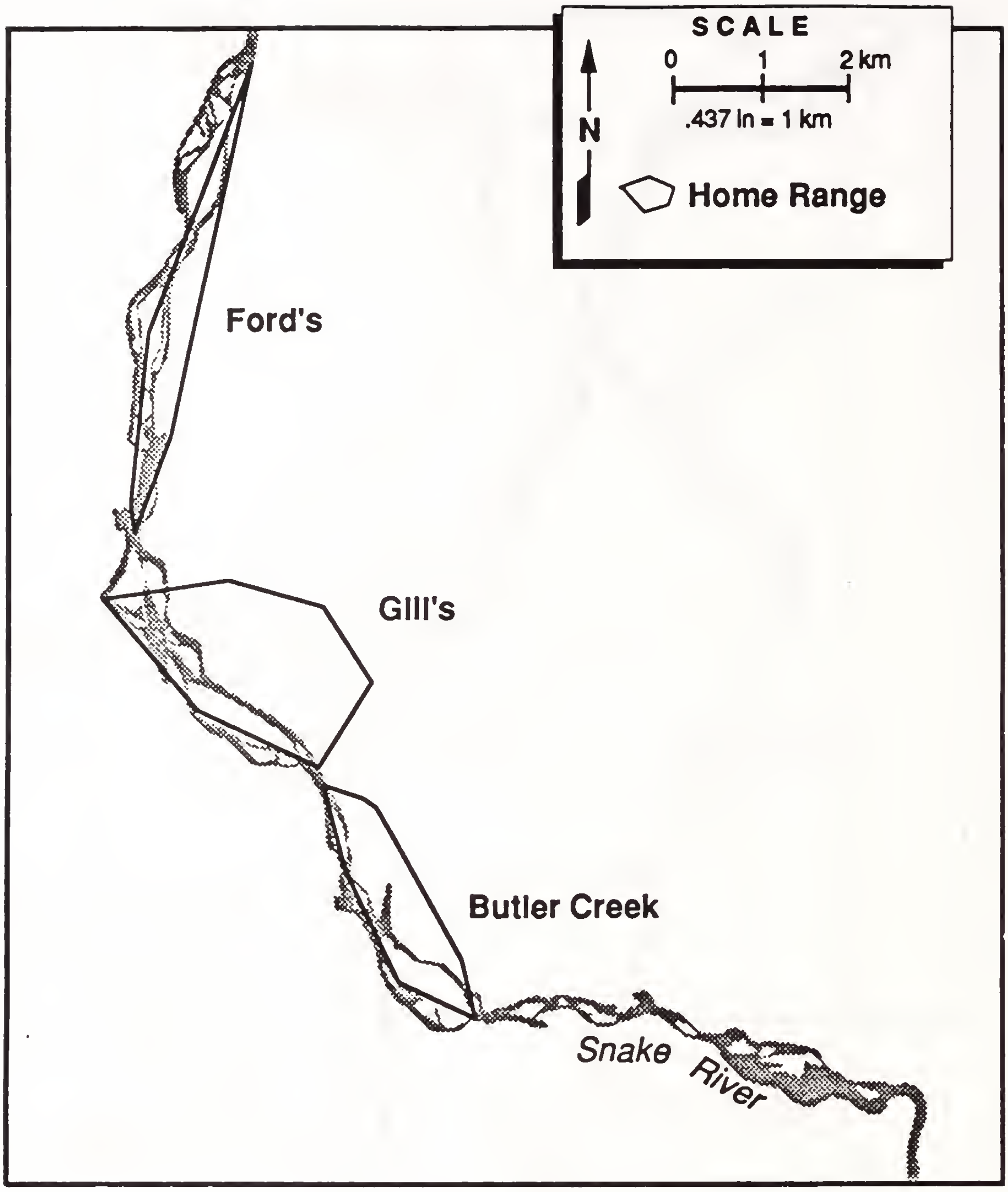

Figure 28. Home ranges of adult bald eagles associated with 3 nest sites in South Park, Wyoming, as determined visually.

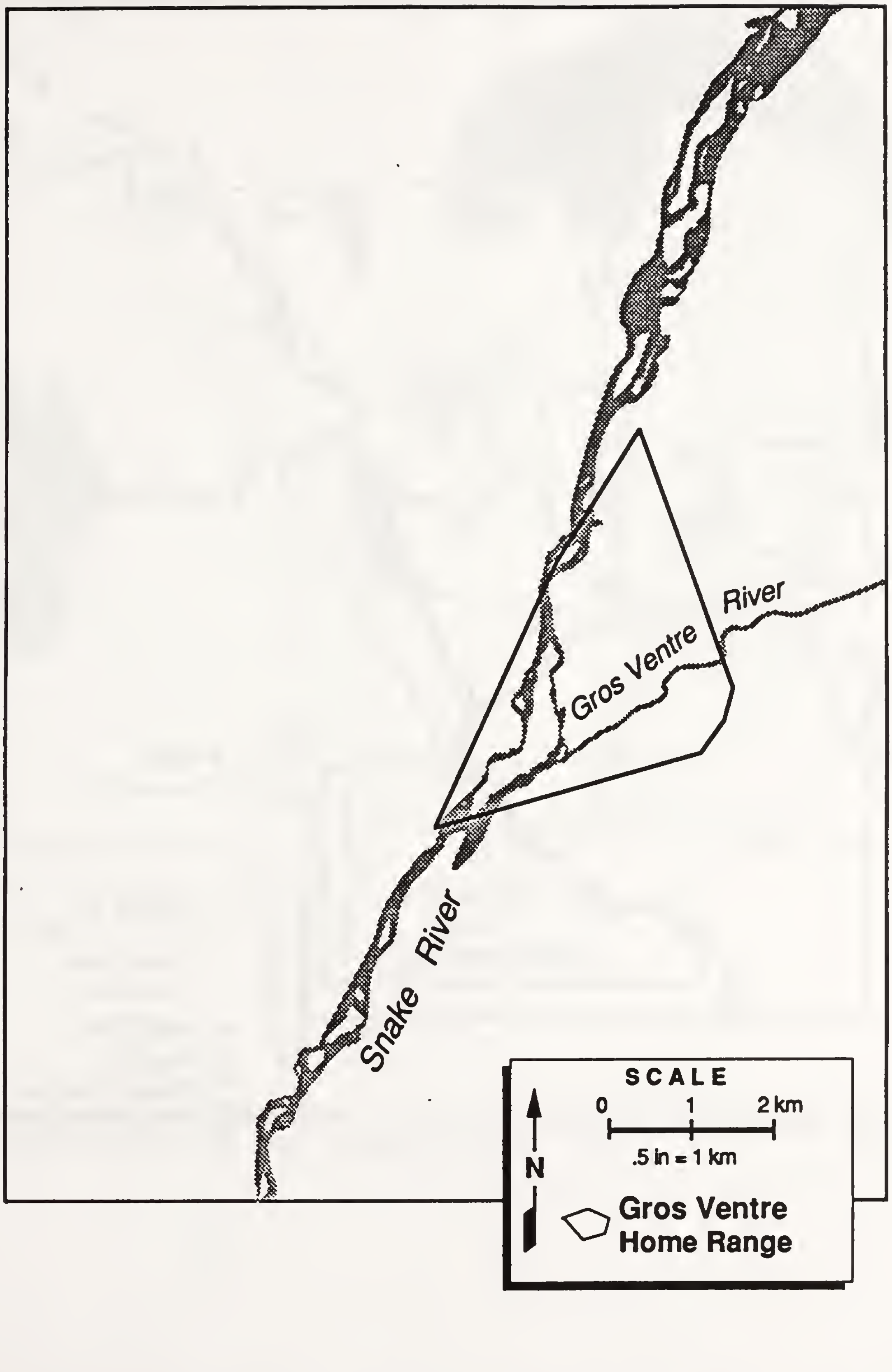

Figure 29. Home range of adult bald eagles associated with the Gros Ventre nest site, South Park, Wyoming, 1980-1981, as determined visually.

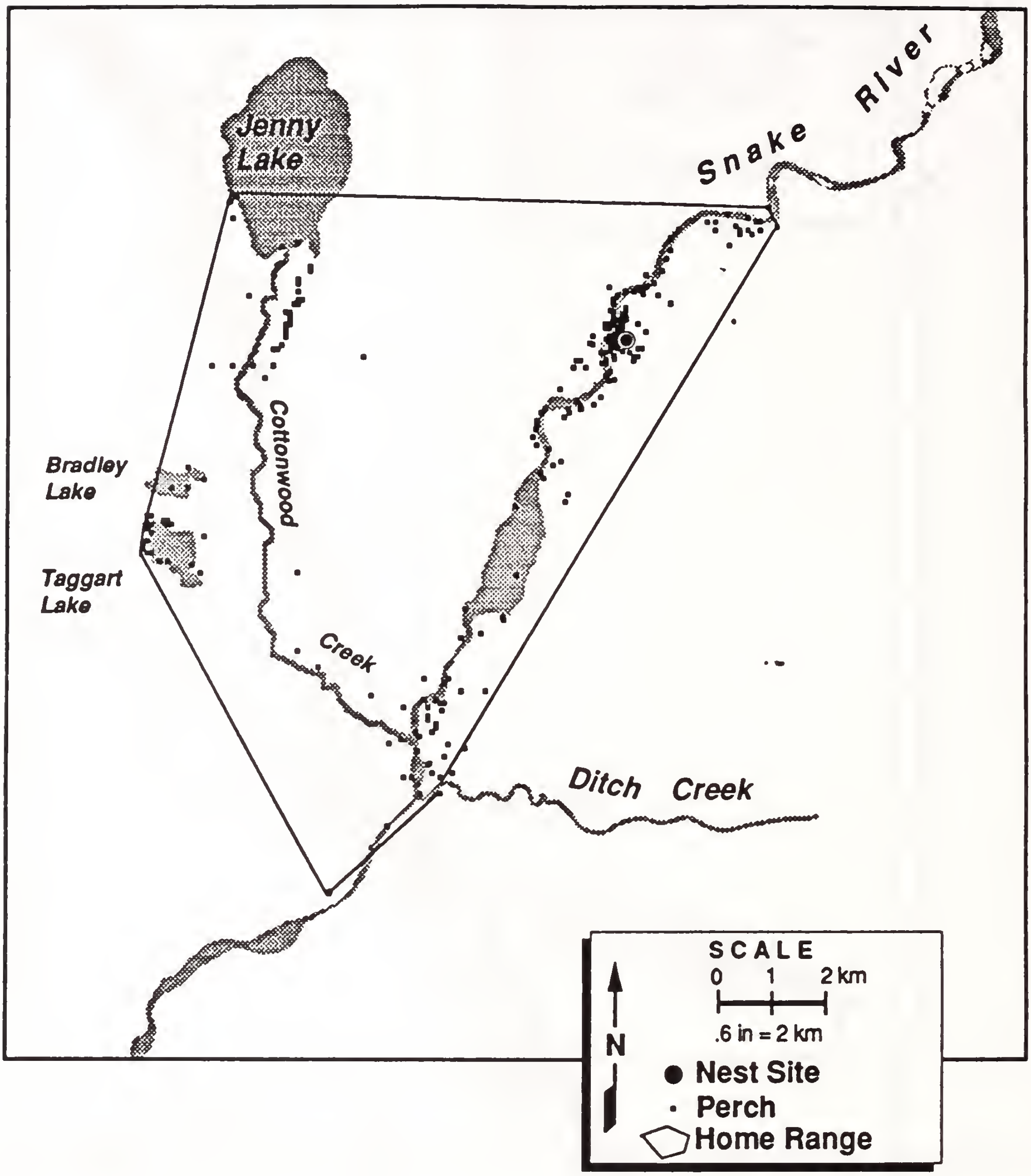

Figure 30. Home range and perch sites of adult male bald eagle associated with the Schwabacher nest site, Snake Teton, Wyoming, 1987 and 1989.

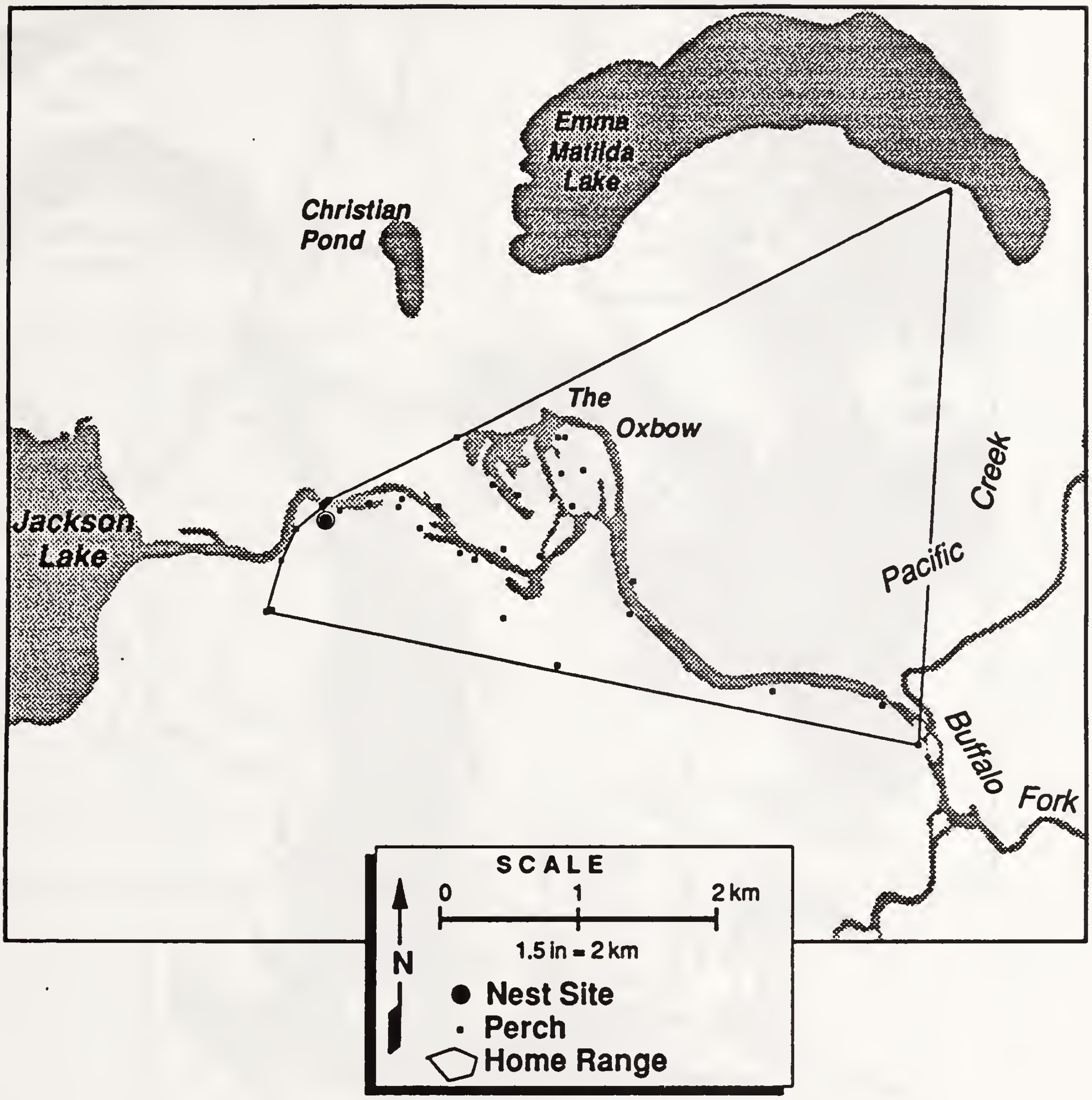

Figure 31. Home range and perch sites of adult male bald eagle associated with the Oxbow nest site, Grand Teton National Park, Wyoming, 1988.

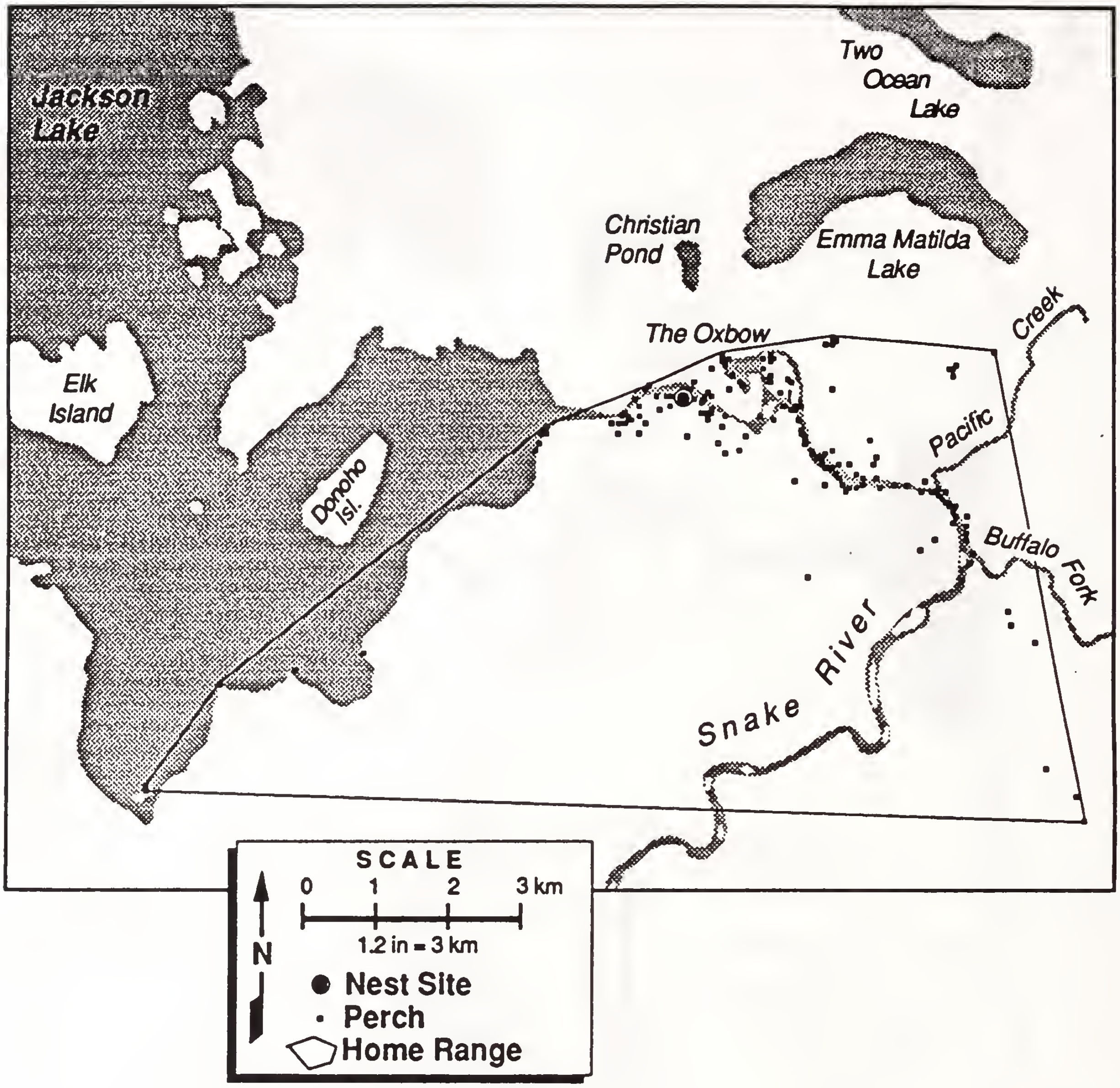

Figure 32. Home range and perch sites of adult female bald eagle associated with the Oxbow nest site, Grand Teton National Park, Wyoming, 1988-1990.

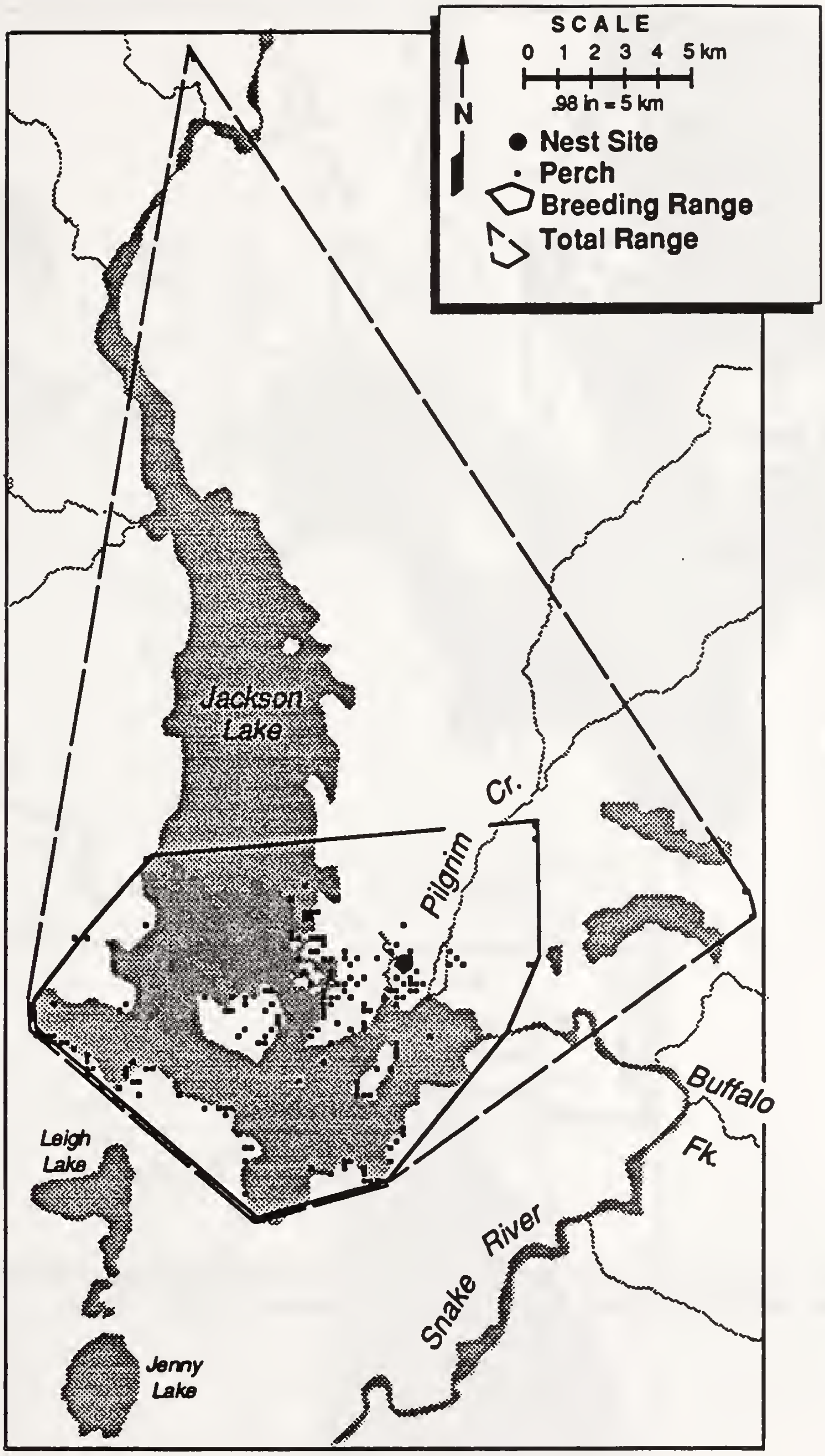

Figure 33. Home range and perch sites of adult male bald eagle associated with the Third Creek nest site, Grand Teton National Park, Wyoming, 1988-1990. Total range includes movements during winter; breeding range includes movements during spring, summer, and autumn only.

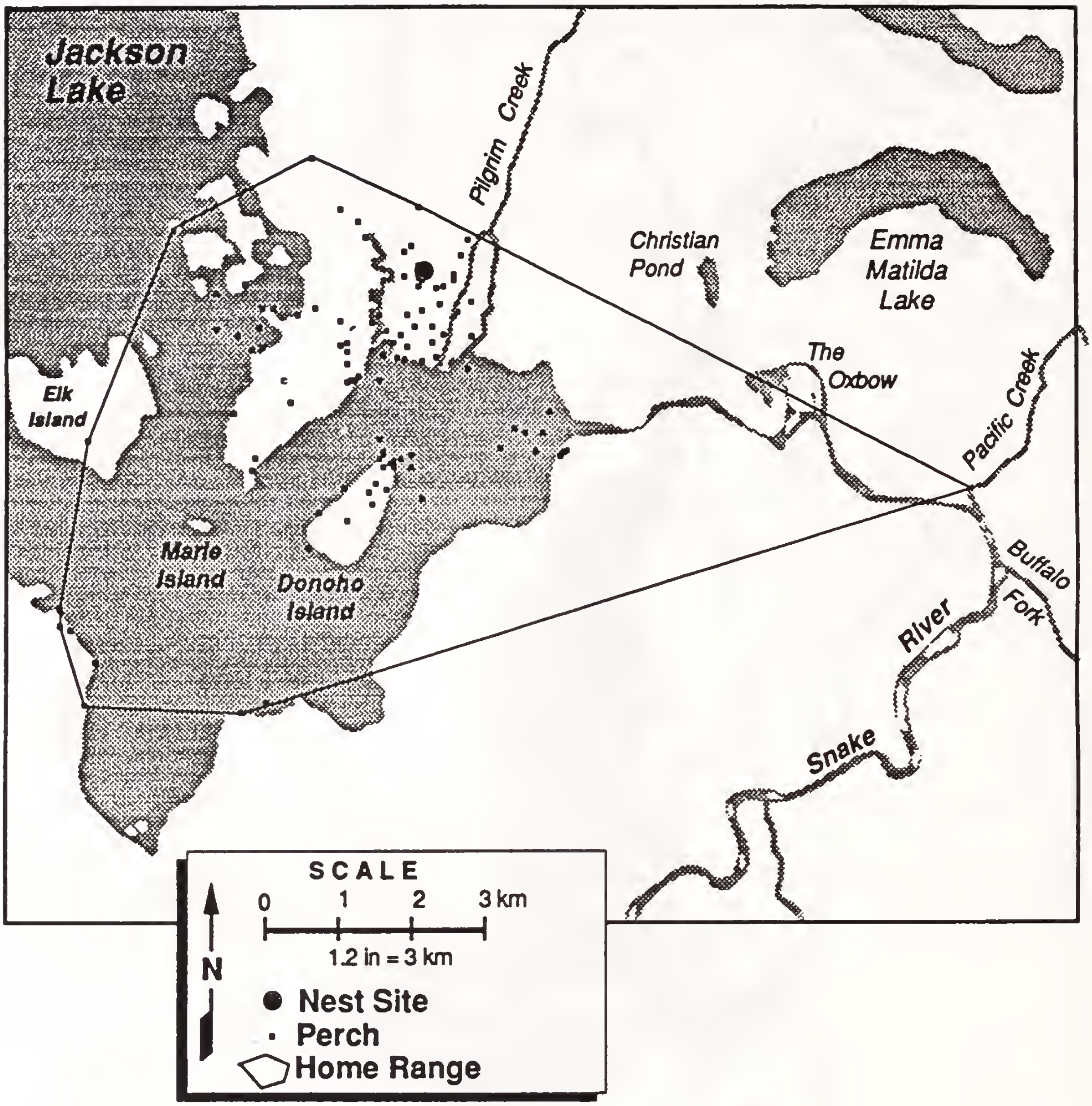

Figure 34. Home range and perch sites of adult female bald eagle associated with the Third Creek nest site, Grand Teton National Park, Wyoming, 1987.

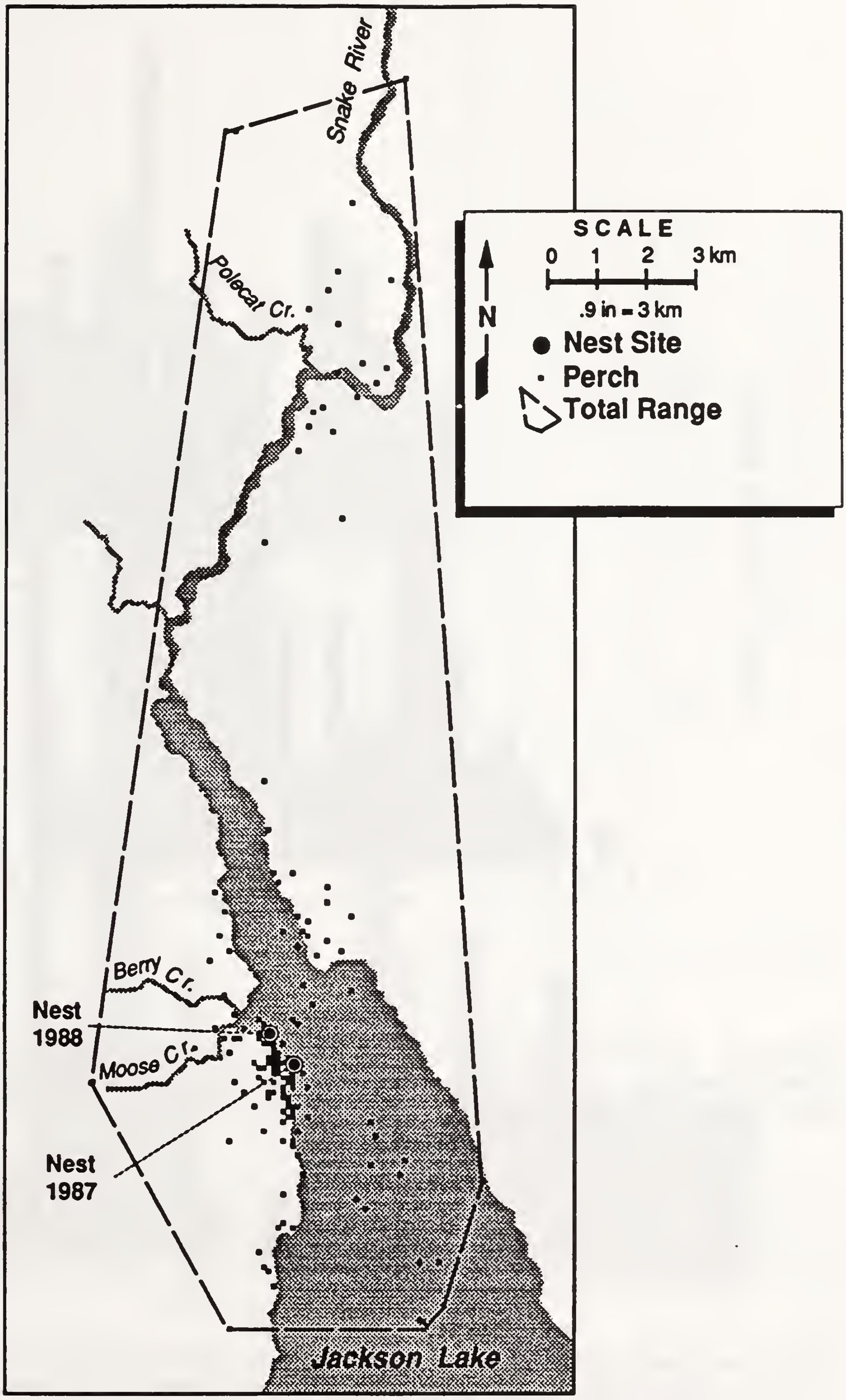

Figure 35. Home range and perch sites of adult male bald eagle associated with the Wilcox Point nest site, Grand Teton National Park, Wyoming, 1988.

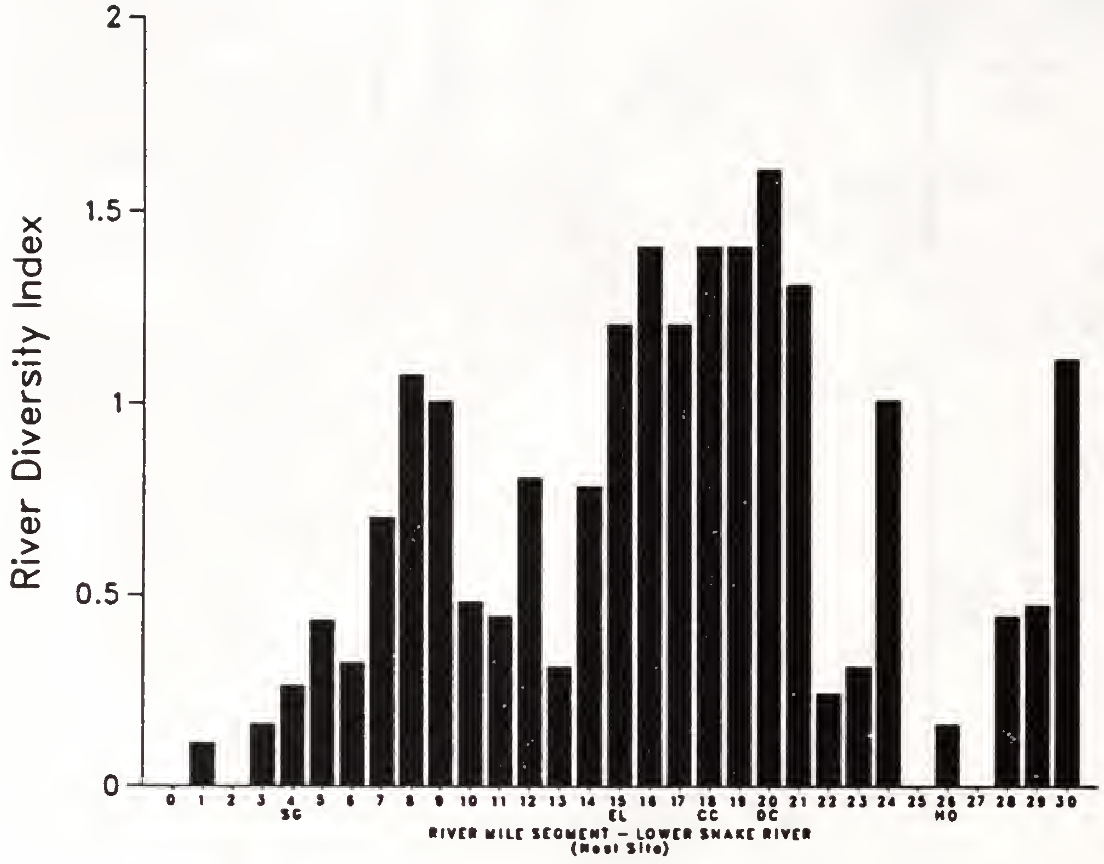

Figure 36. River diversity indexes of River Mile Segments (RMS) 0-30 of the Lower Snake River, Wyoming. Initials representing local eagle pairs' nest are below respective RMS: SG=Sheep Gulch, EL=Elbow, CC=Cabin Creek, DC=Dog Creek, HO=Hoback.

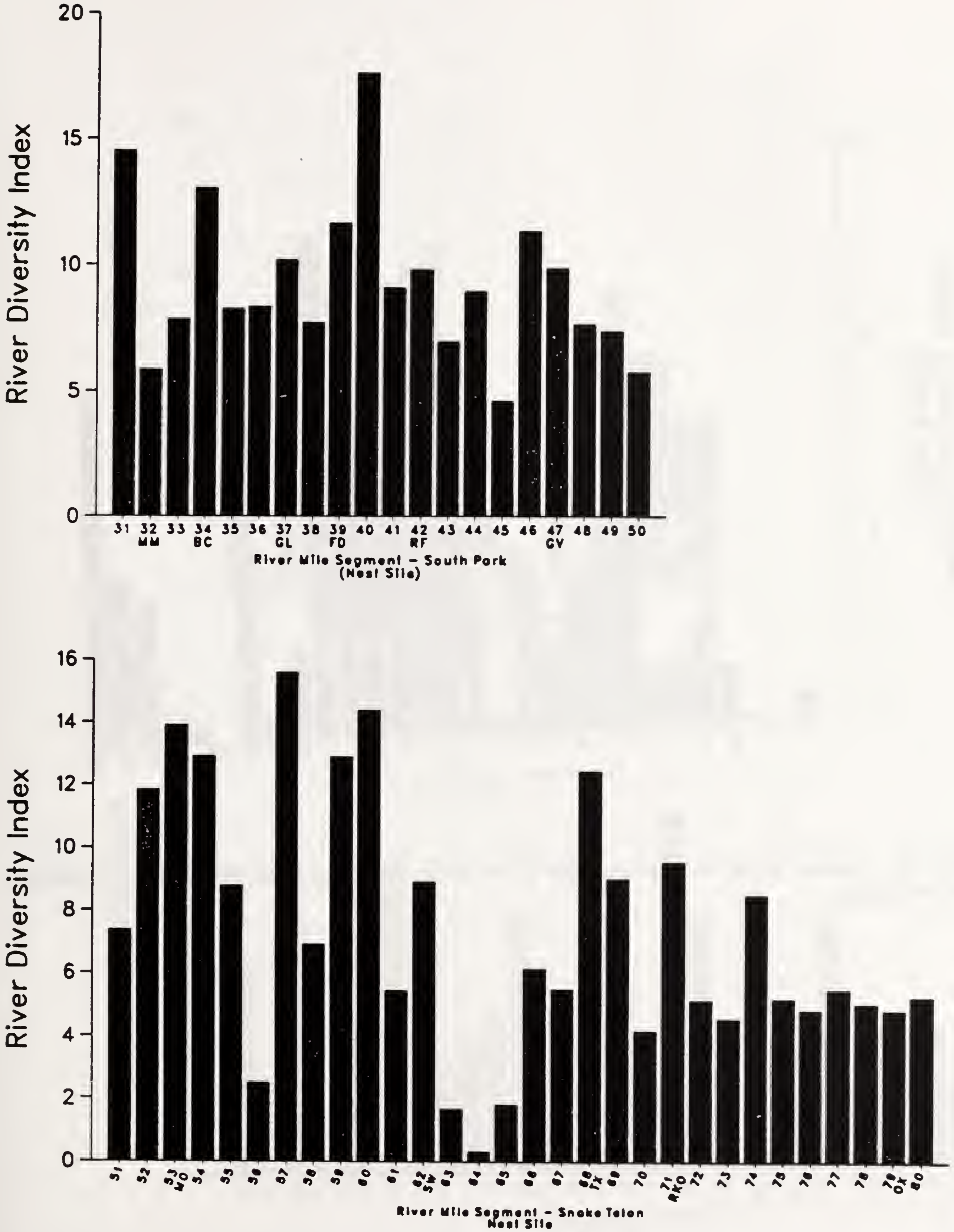

Figure 37. River diversity indexes of River Mile Segments 31-50 (South Park) and 51-80 (Snake Teton) of the Snake River, Wyoming. Initials representing local eagle pairs' nest are below respective RMS: MM=Munger Mtn., BC=Butler Creek, GL=Gill's, FD=Ford's, RF=Refuge, GV=Gros Ventre, MO=Moose, SW=Schwabacher, TX=Triangle X, RKO, OX=Oxbow.

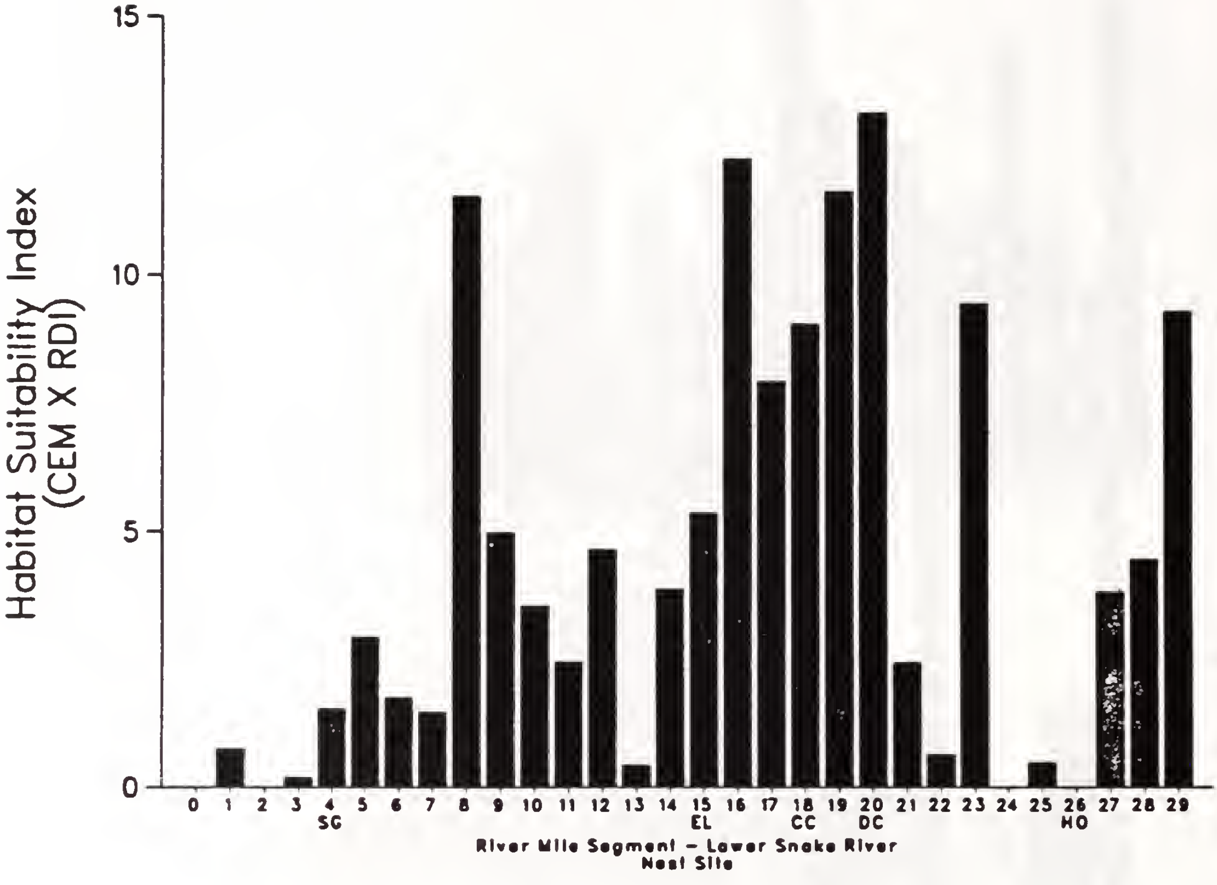

Figure 38. Habitat suitability indexes for River Mile Segments 0-30 of the Lower Snake River, Wyoming.

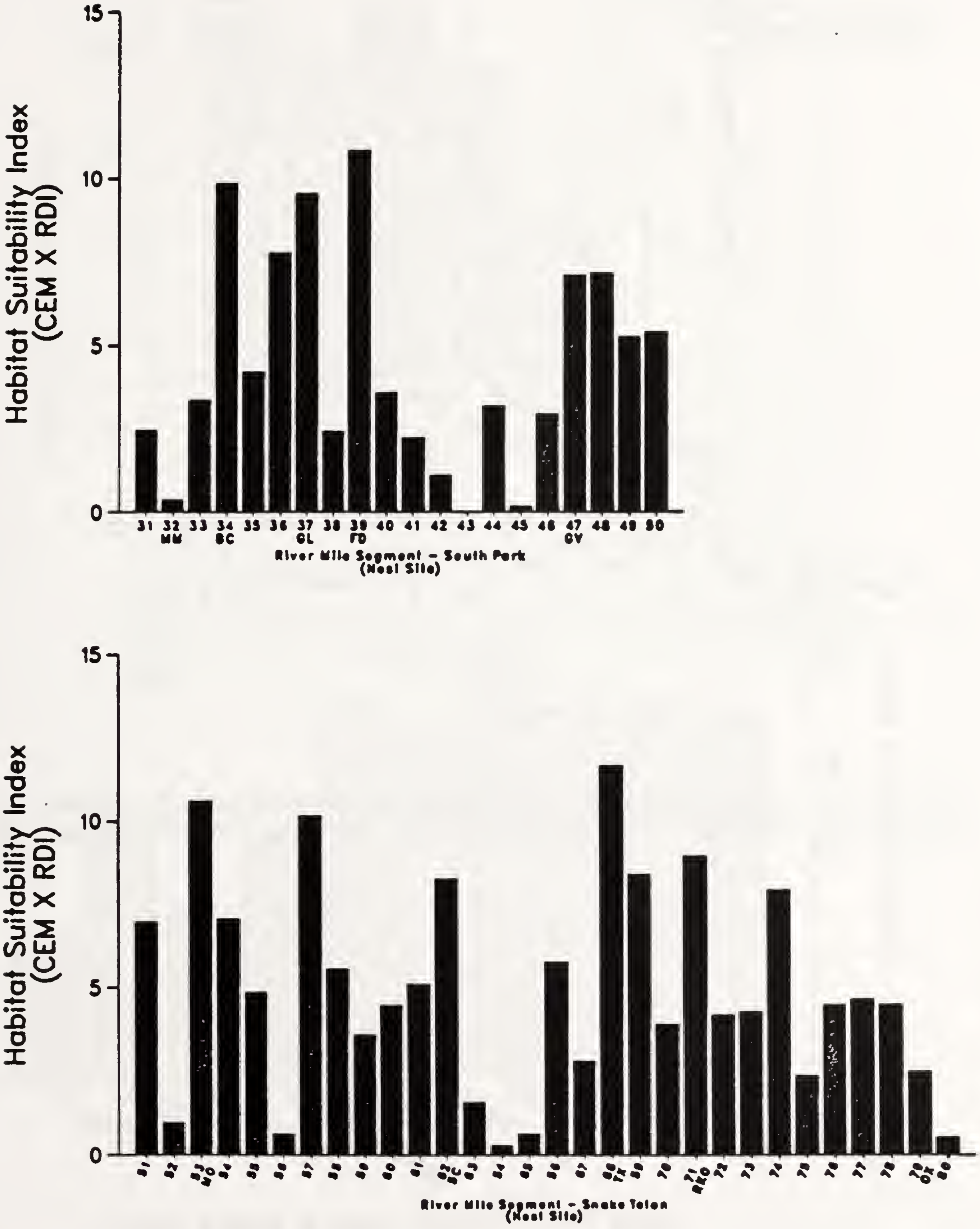

Figure 39. Habitat suitability indexes for River Mile Segments 31-50 (South Park) and 51-80 (Snake Teton) of the Snake River, South Park, Wyoming.

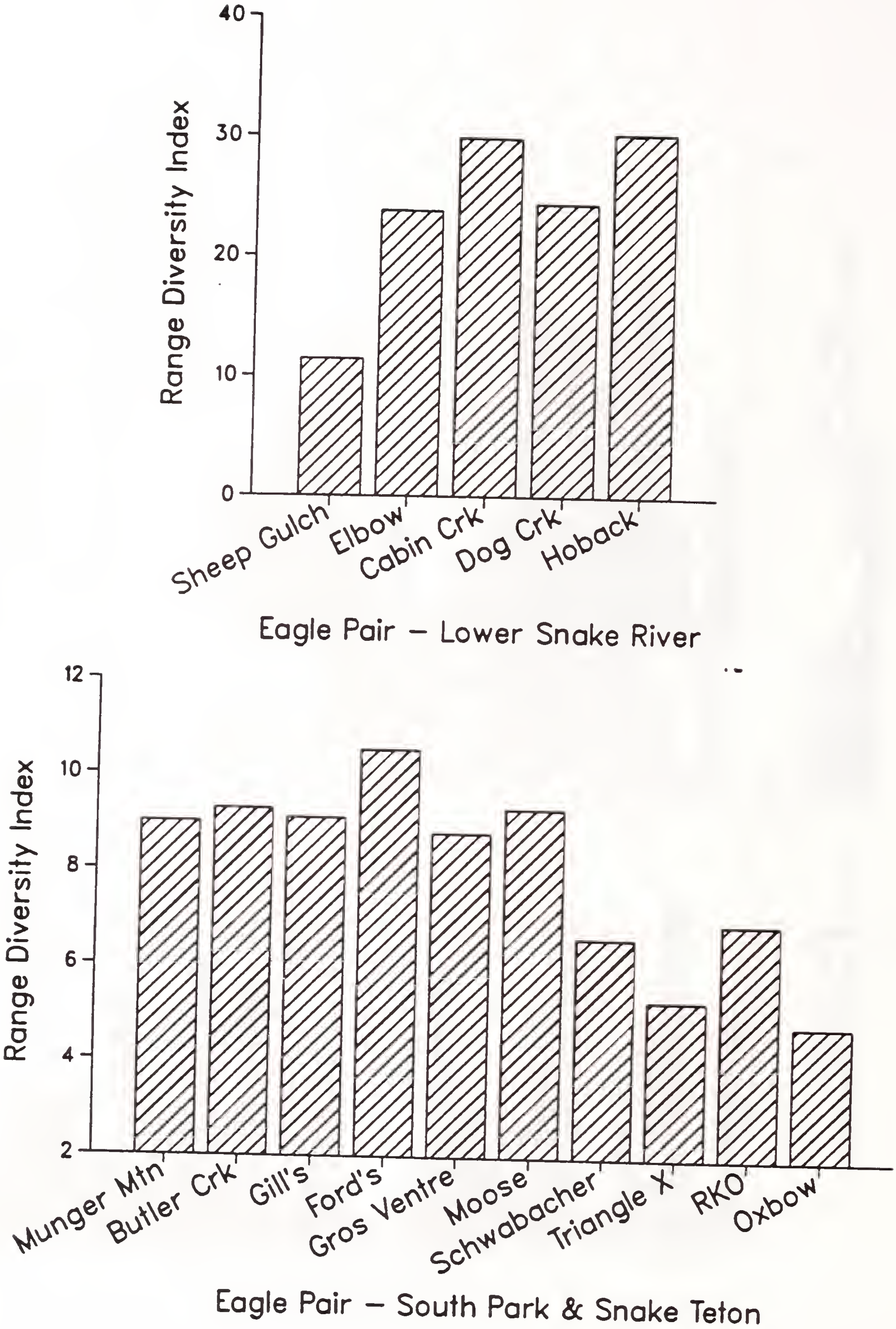

Figure 40. Home range diversity indexes for bald eagle home ranges along the Lower Snake River, Wyoming.

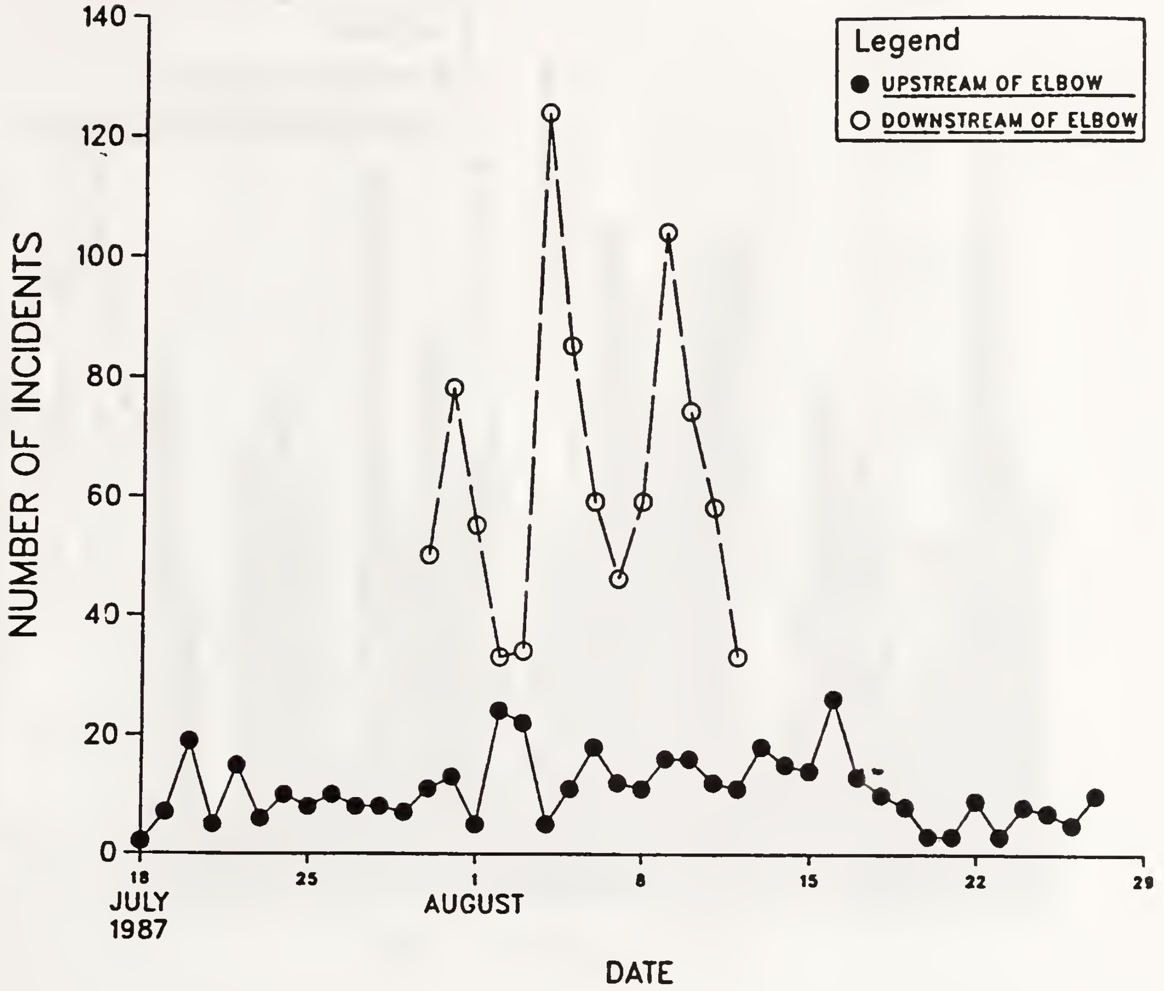

Figure 41. Number of incidents of summer recreational boat traffic (instances boats were in time lapse camera view) in 2 sections of the Lower Snake River, Wyoming, 18 July to 28 August 1987.

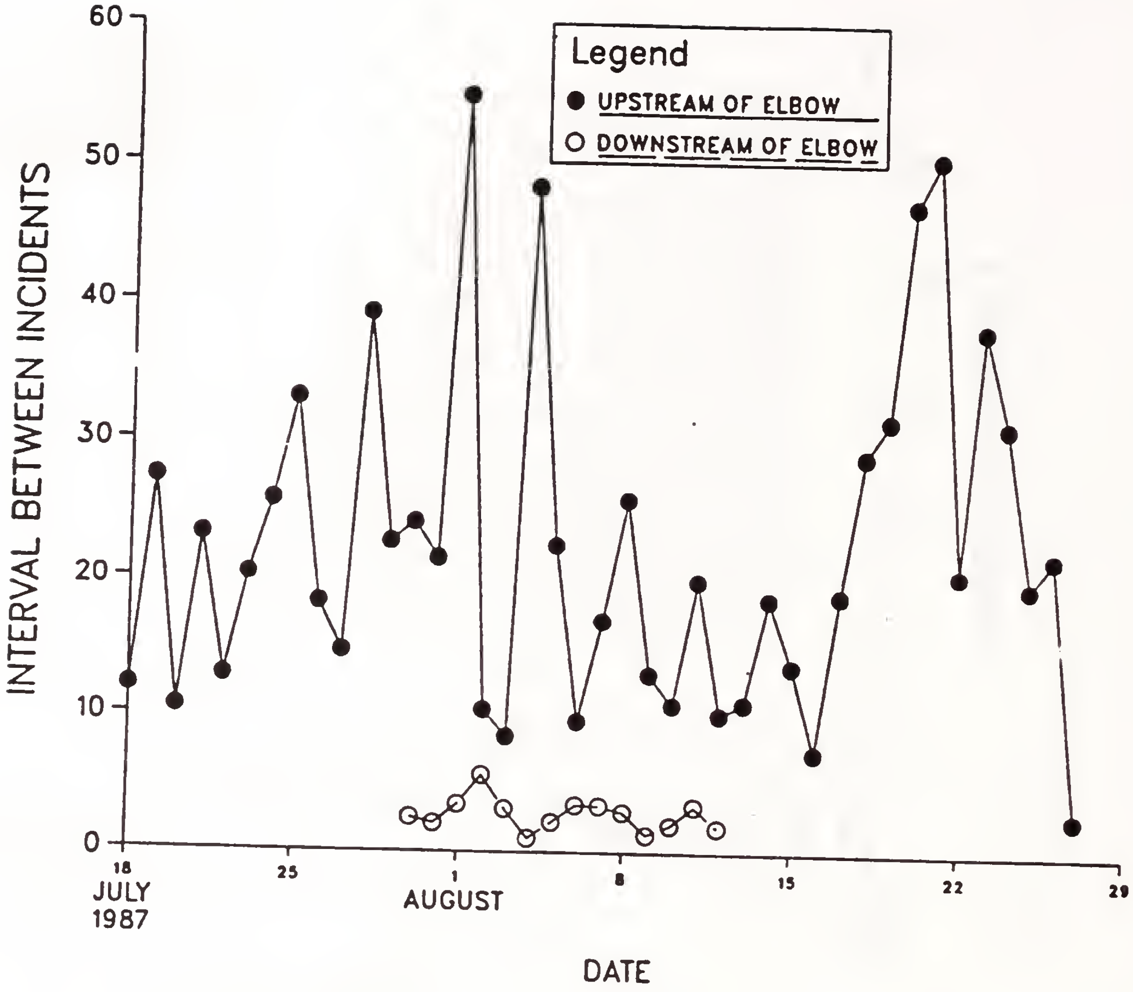

Figure 42. Intervals (minutes no boats were in time lapse camera view) between summer recreational boat traffic in 2 sections of the Lower Snake River, Wyoming, 18 July to 28 August 1987.

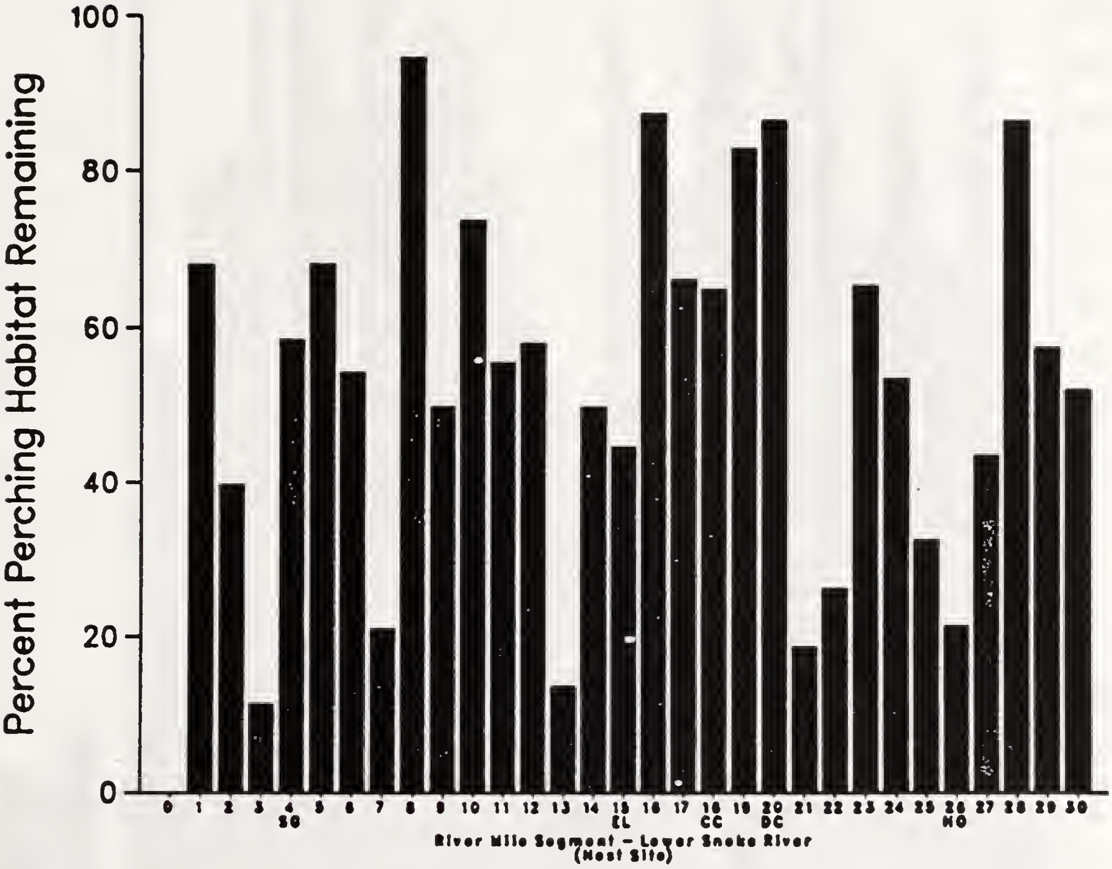

Figure 43. Percent perching habitat remaining per River Mile Segment of the Lower Snake River, Wyoming, as determined by Cumulative Effects Model (Montopoli 1988).

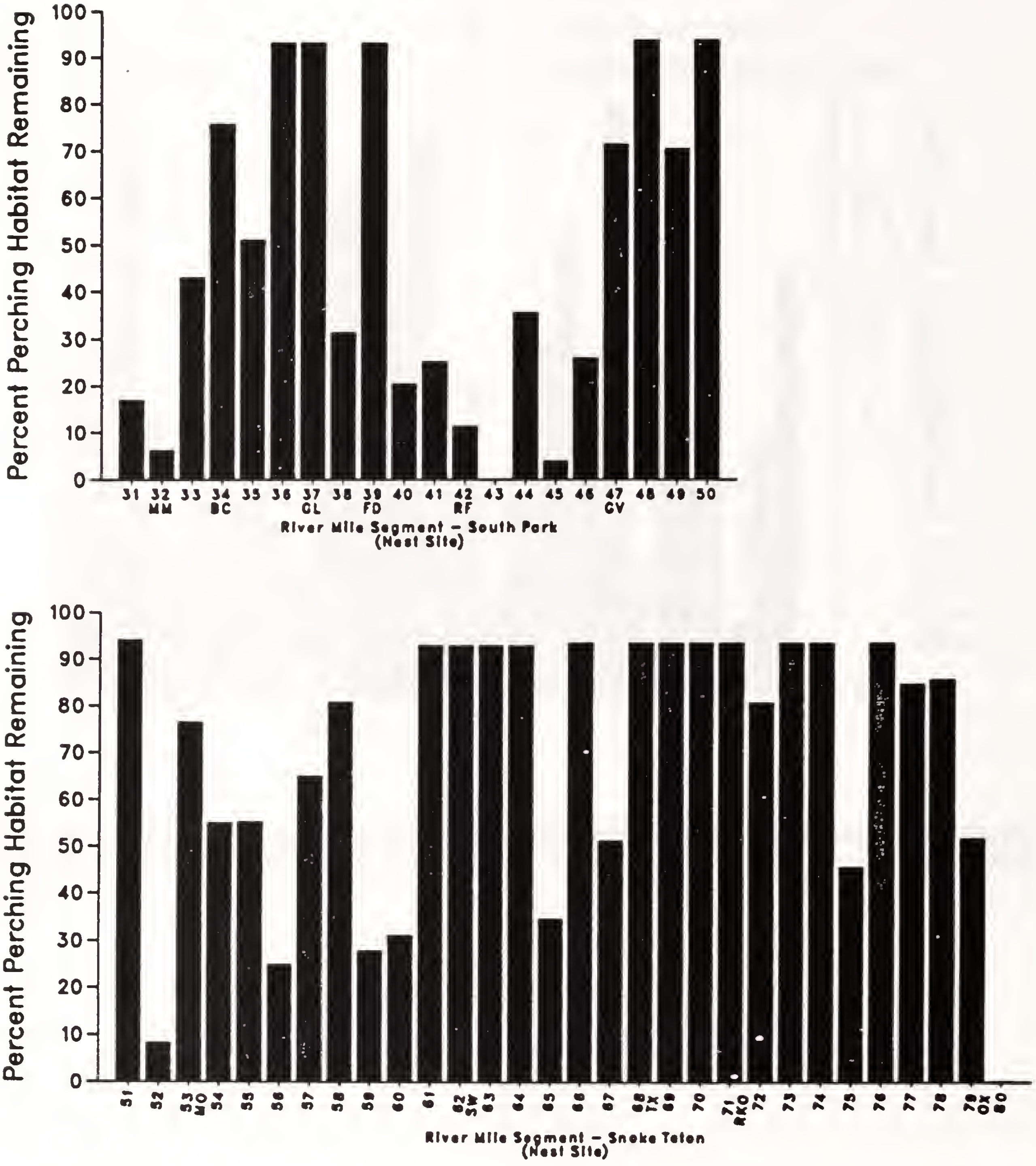

Figure 44. Percent perching habitat remaining per River Mile Segment of the Snake River in South Park and Snake Teton, Wyoming.

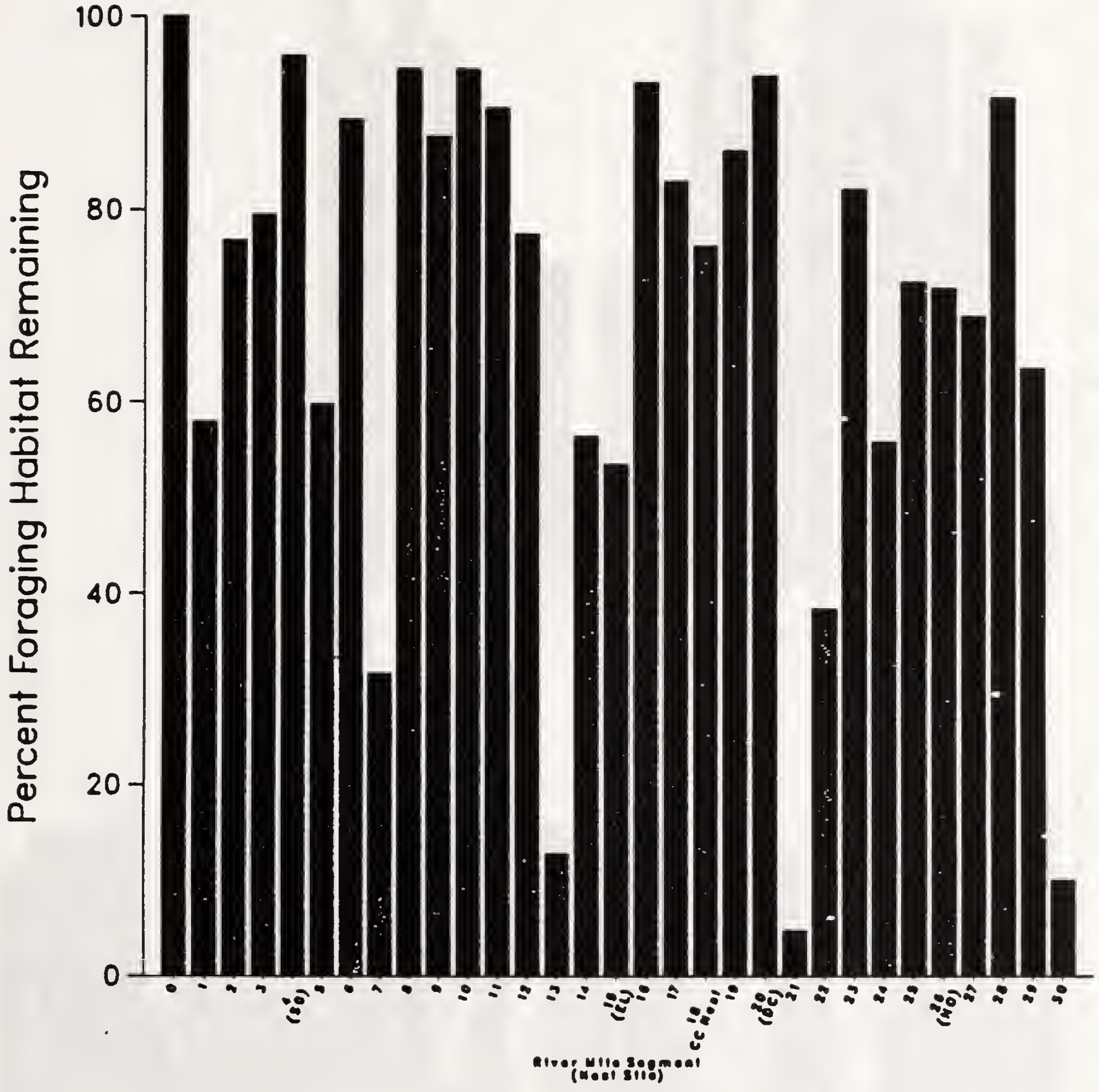

Figure 45. Percent foraging habitat remaining per River Mile Segment of the Snake River in Lower Snake River, Wyoming.

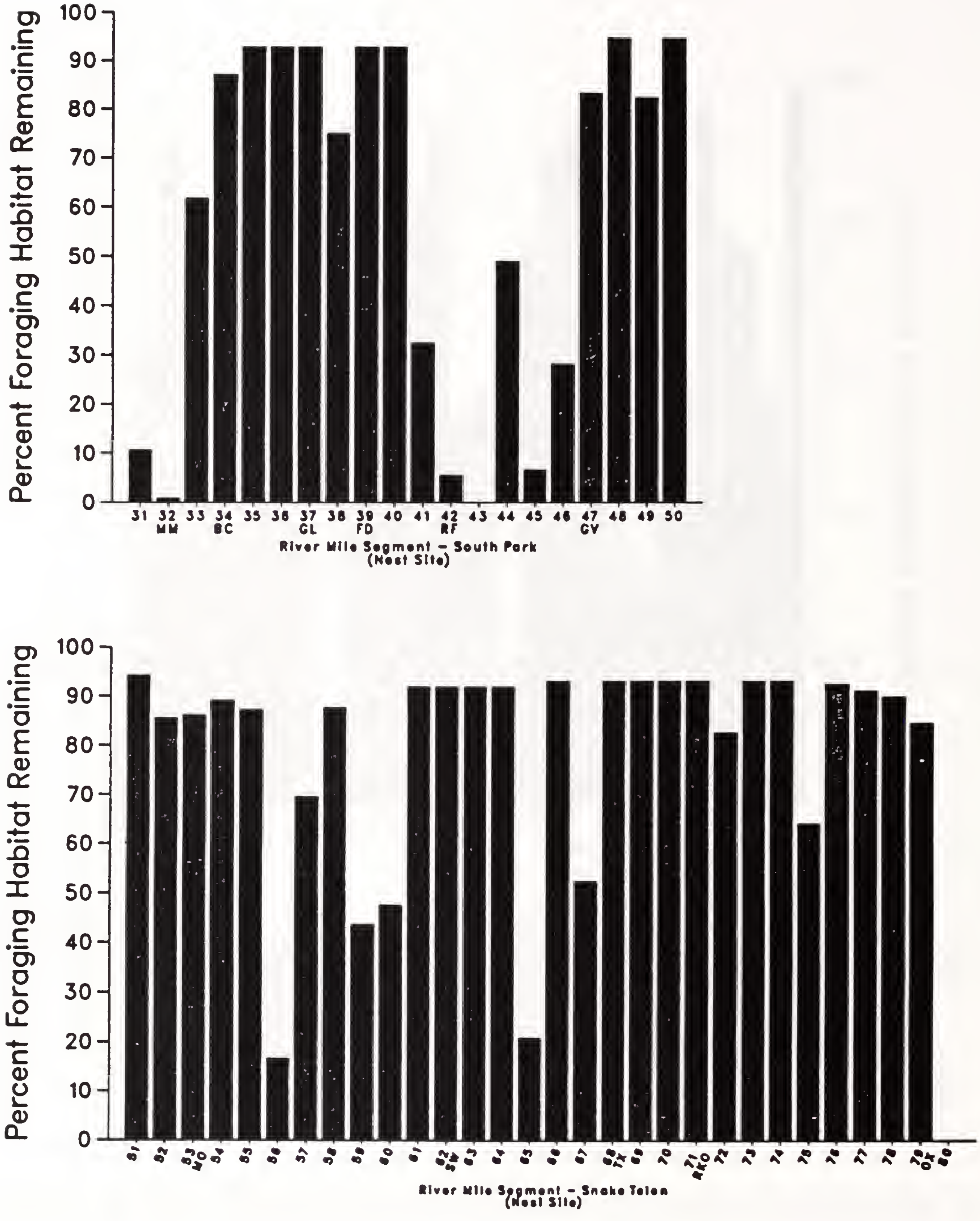

Figure 46. Percent foraging habitat remaining per River Mile Segment of the Snake River in South Park and Snake Teton portion of the Greater Yellowstone Ecosystem, Wyoming.

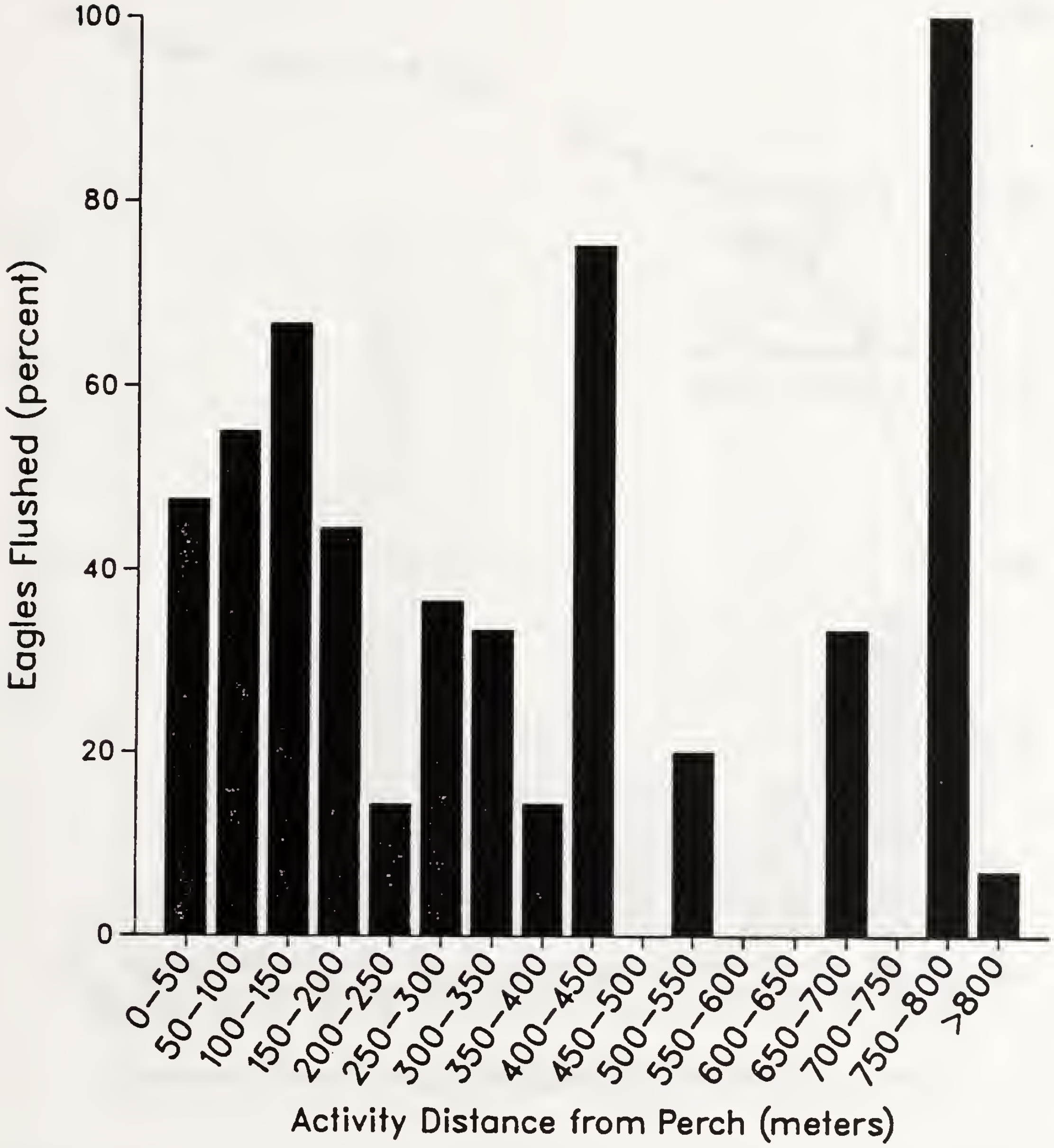

Figure 47. Proportion of total encounters with all types of human activity (see text) during which resident bald eagles flushed, by distance class. Sample size is indicated within the top of each bar.

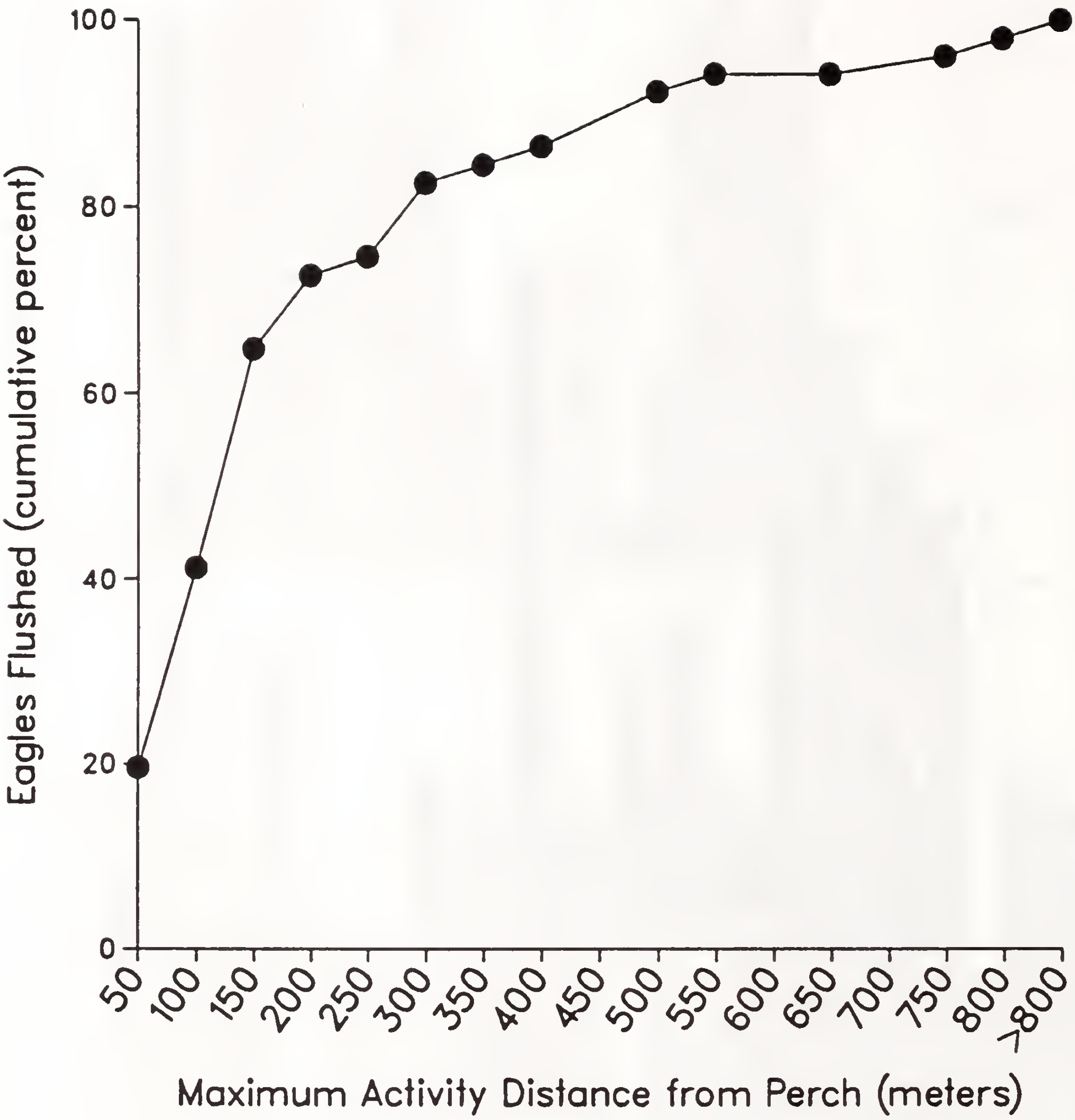

Figure 48. Cumulative percent of all resident bald eagles flushed in the Greater Yellowstone Ecosystem, by distance class, 1985-1989.

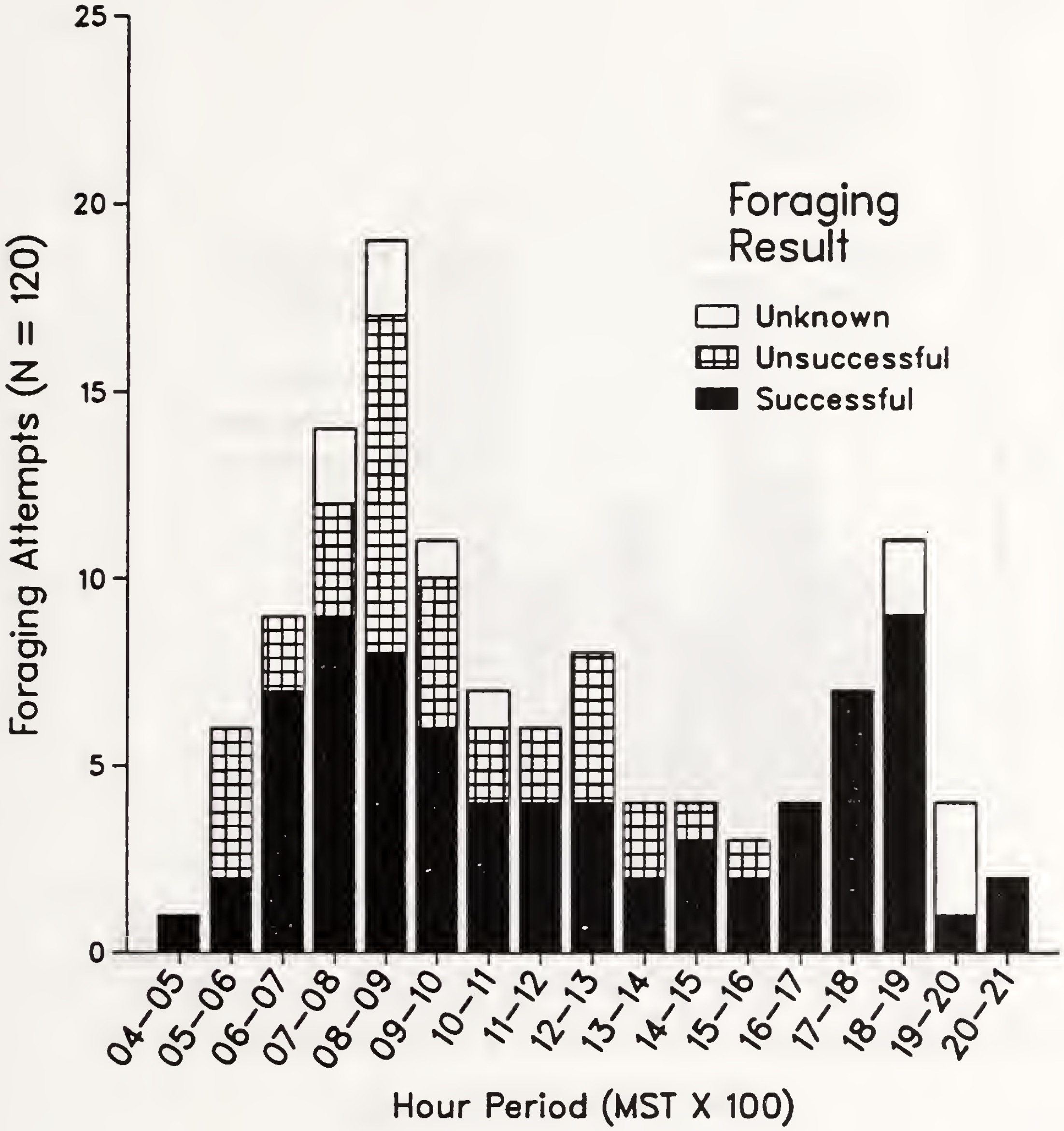

Figure 49. Foraging attempts per hour period for bald eagles along the Lower Snake River, Wyoming, 1985-1989.

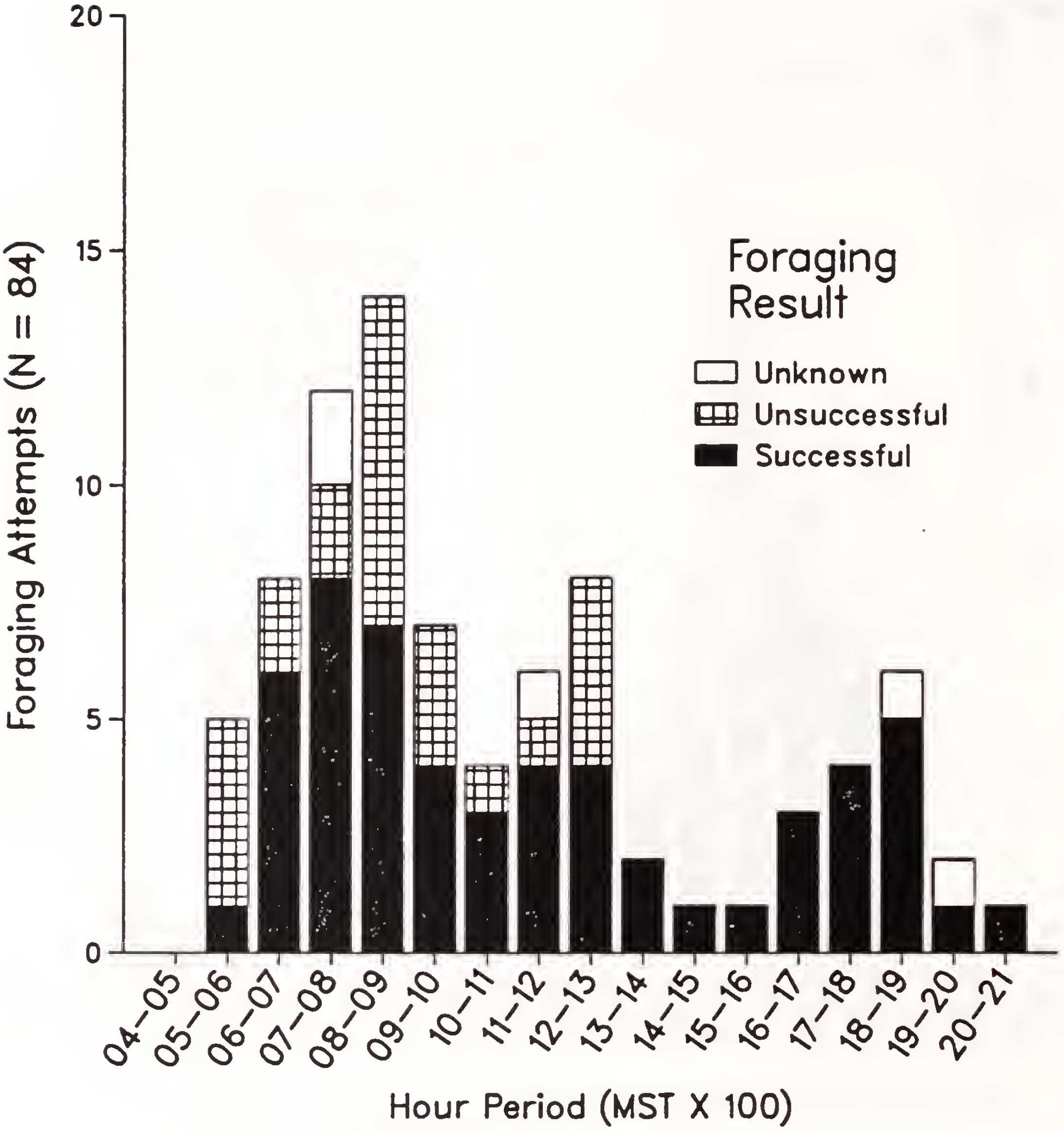

Figure 50. Foraging success of radio-tagged bald eagles resident in the Lower Snake River, Wyoming, by hour period, 1985-1989.

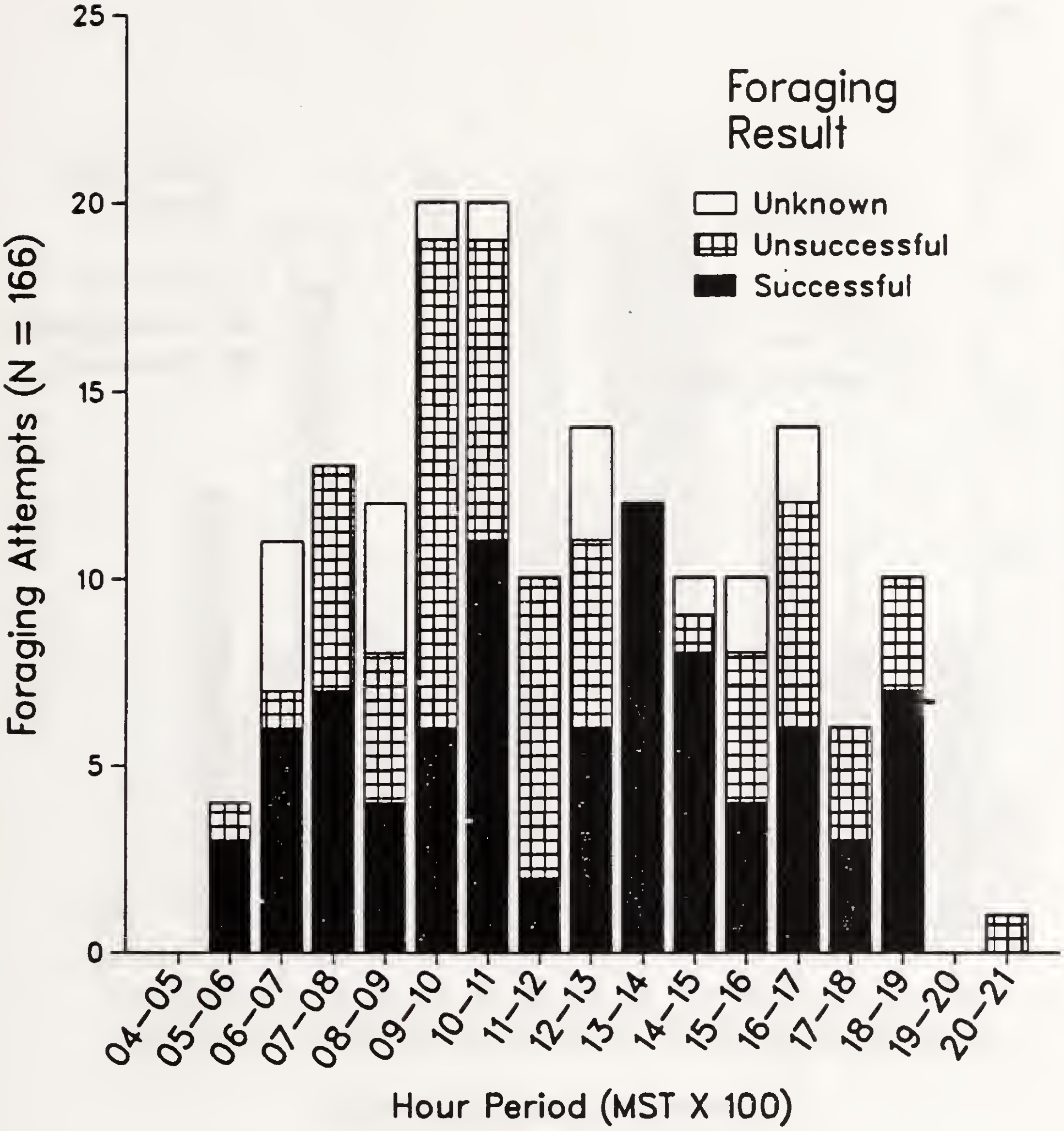

Figure 51. Foraging succes per hour period of bald eagles in Snake Teton, Wyoming, 1986-1989.

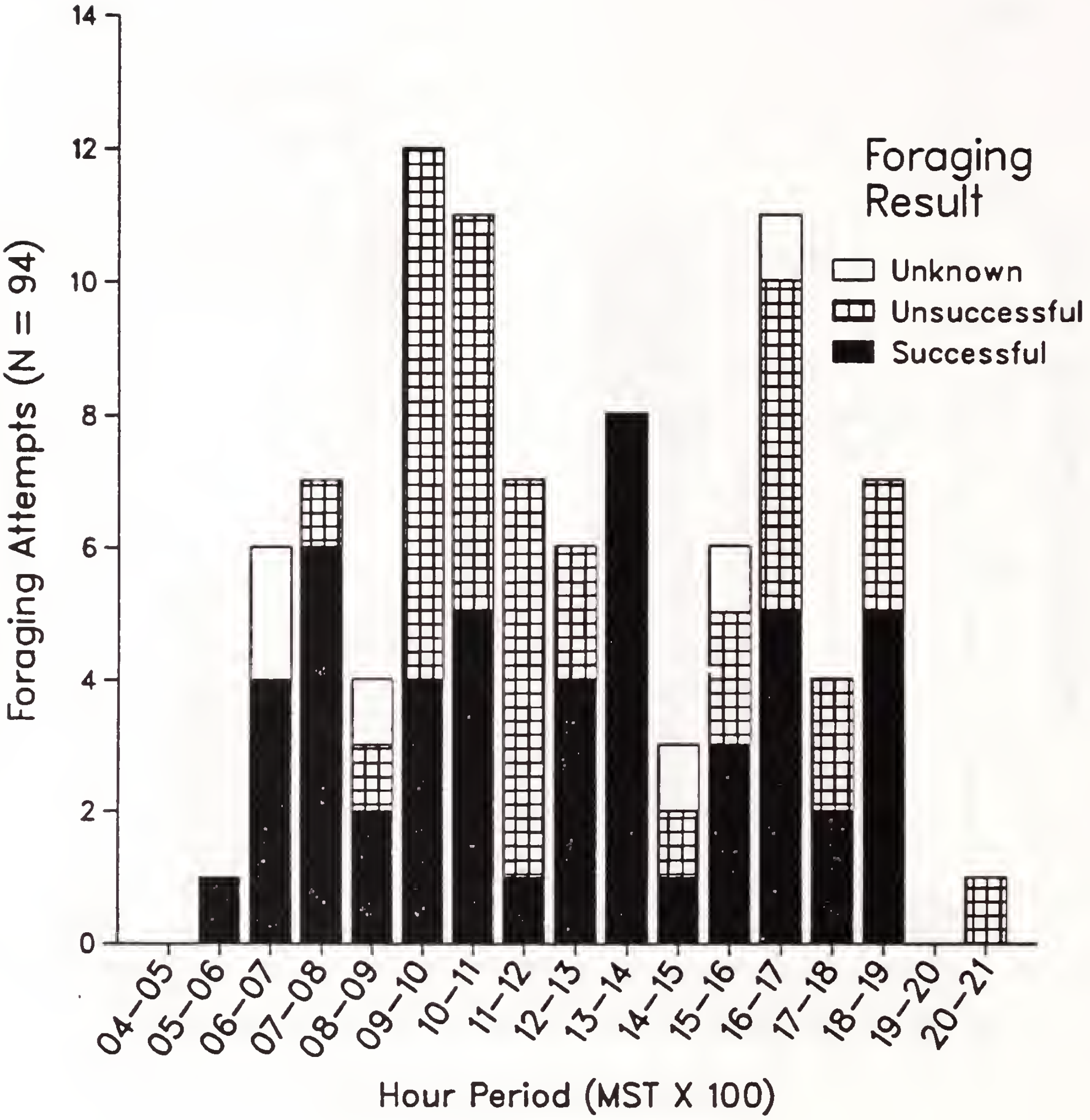

Figure 52. Foraging success per hour period of bald eagles radio-tagged and resident in Snake Teton, Wyoming.

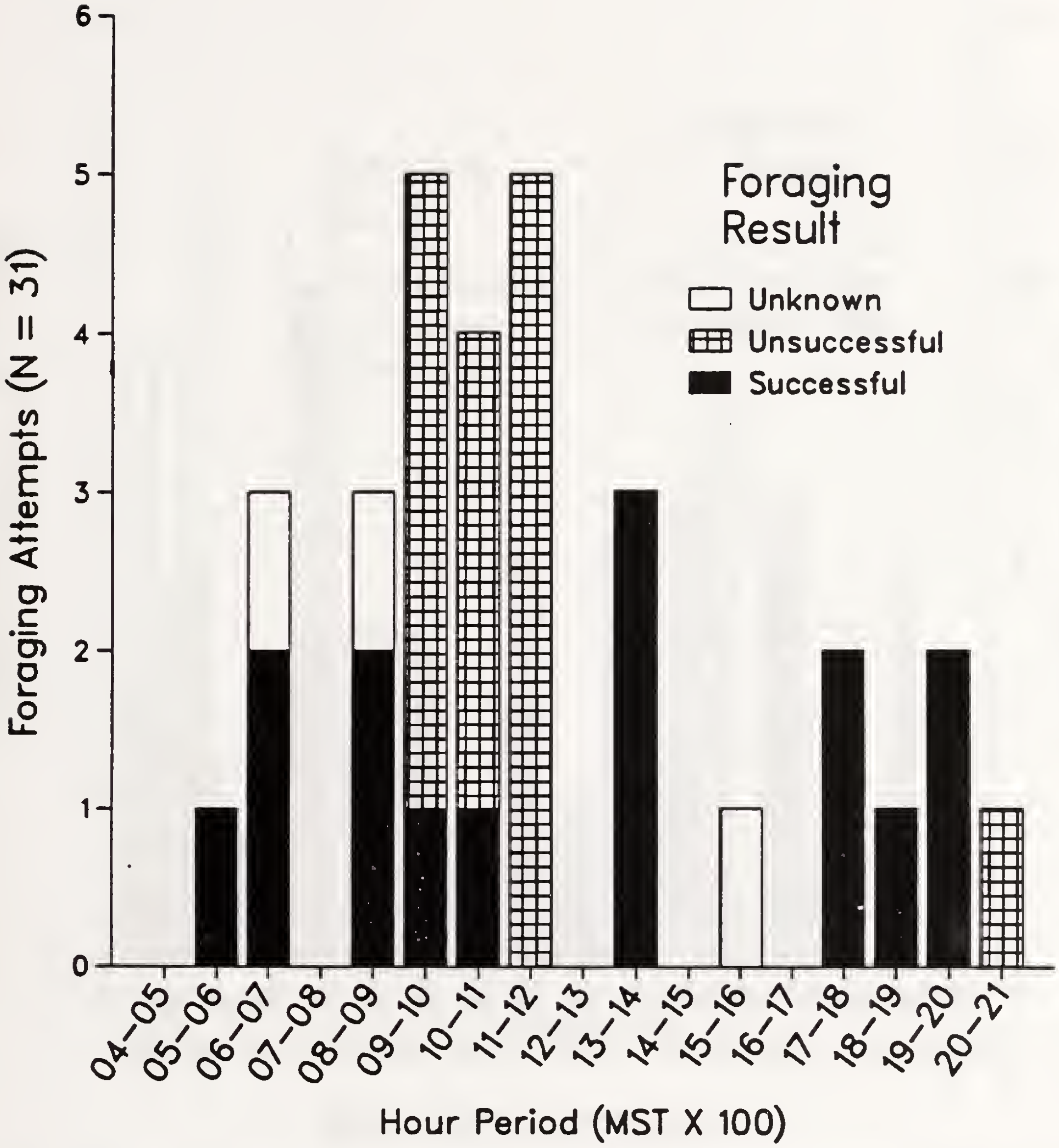

Figure 53. Summer foraging success of radio-tagged adult bald eagles resident in Snake Teton, Wyoming.

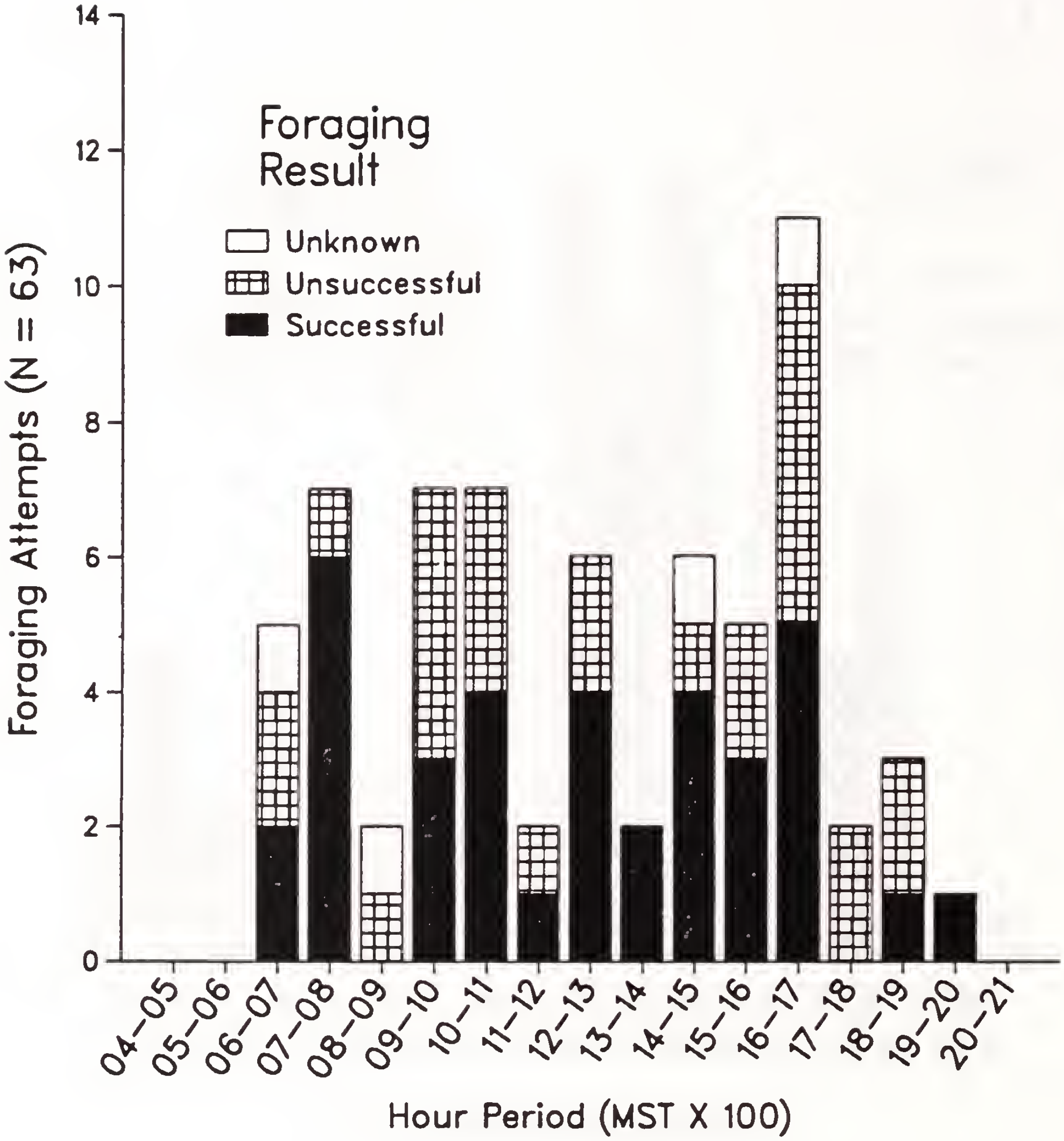

Figure 54. Winter foraging success of radio-tagged adult bald eagles resident in Snake Teton, Wyoming.

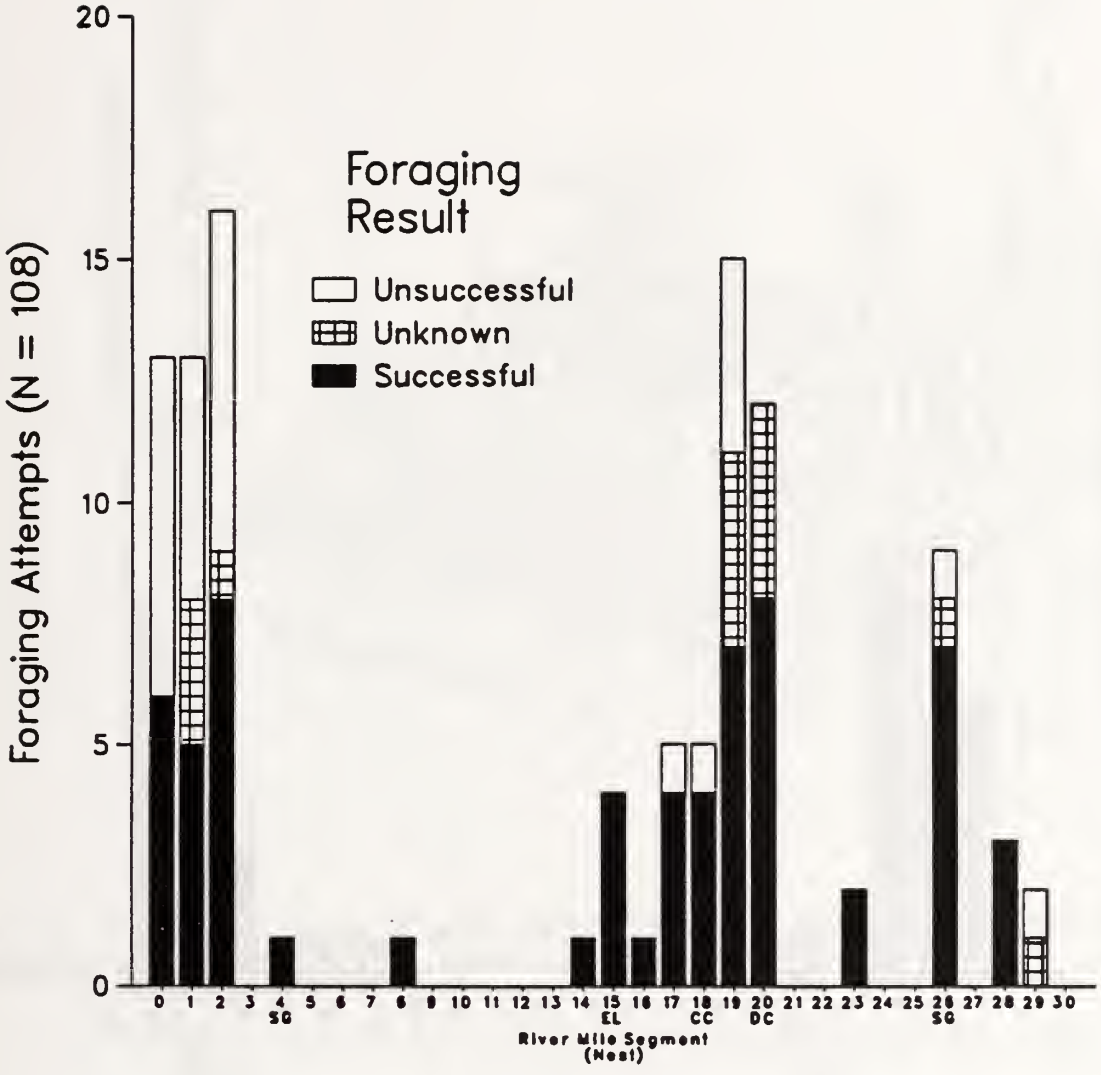

Figure 55. Foraging attempts for bald eagles per River Mile Segment of the Lower Snake River, Wyoming.

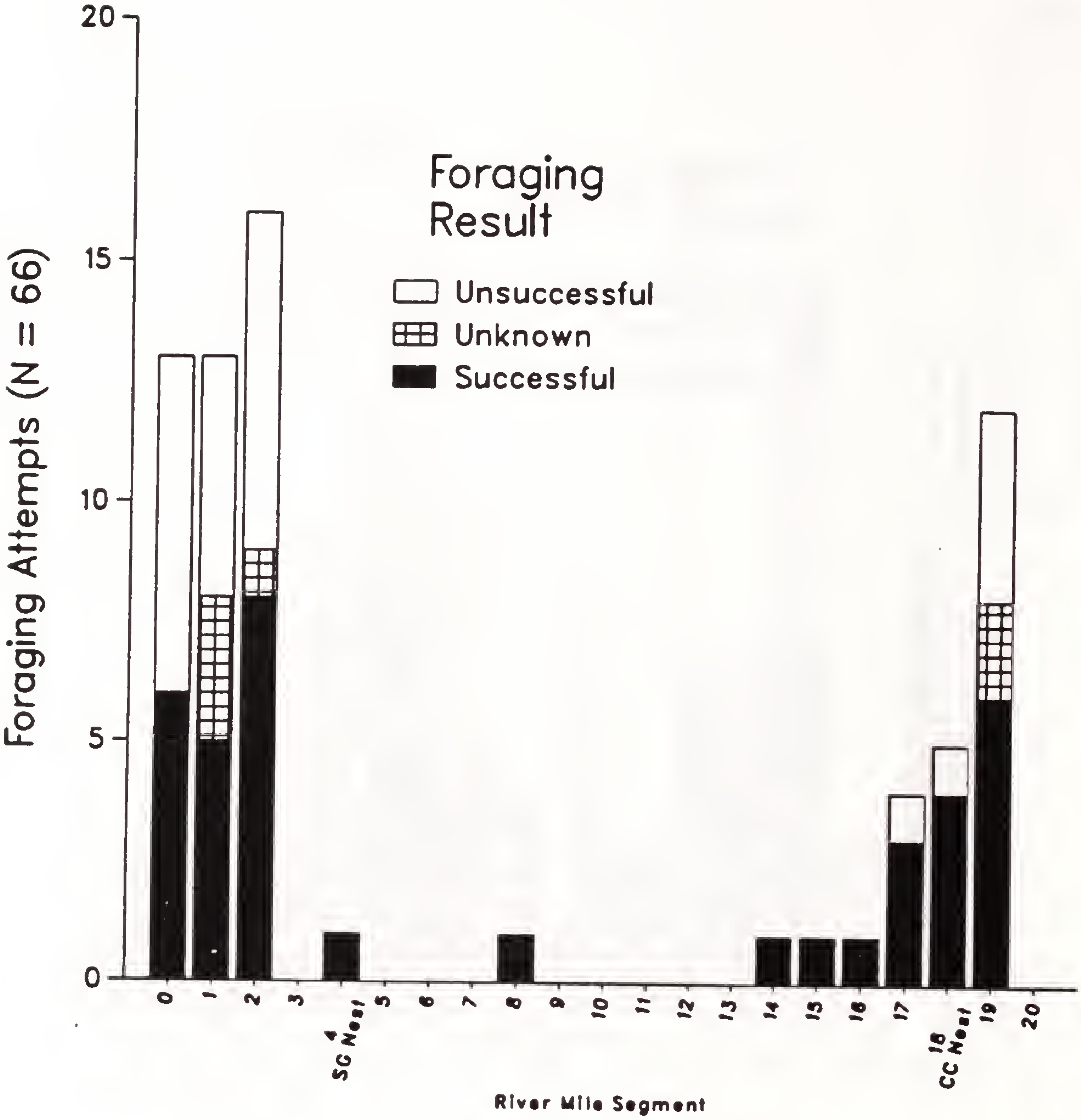

Figure 56. Foraging attempts per River Mile Segment of the Lower Snake River, Wyoming included in home ranges of radio-tagged Cabin Creek and Sheep Gulch adult male bald eagles, resident in adjacent breeding areas, 1986.

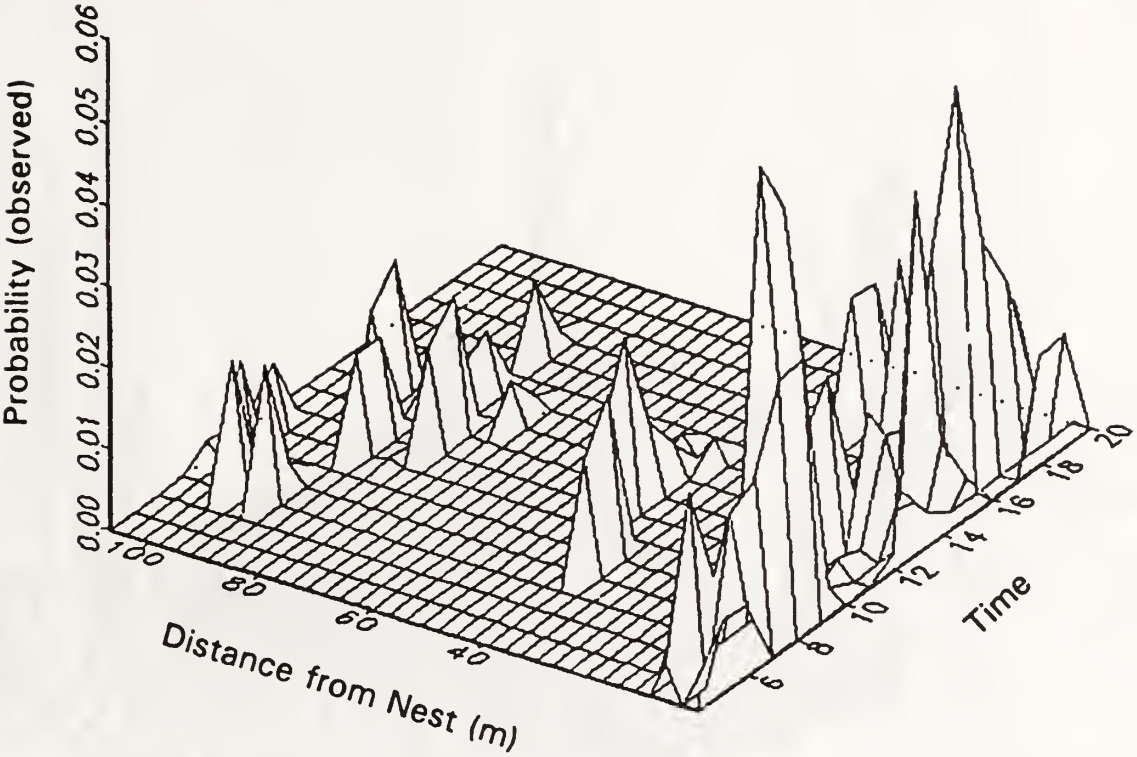

Figure 57. Probability matrix of perch distance from the active nest by hour period for Schwabacher adult male bald eagle, Snake Teton, Wyoming.

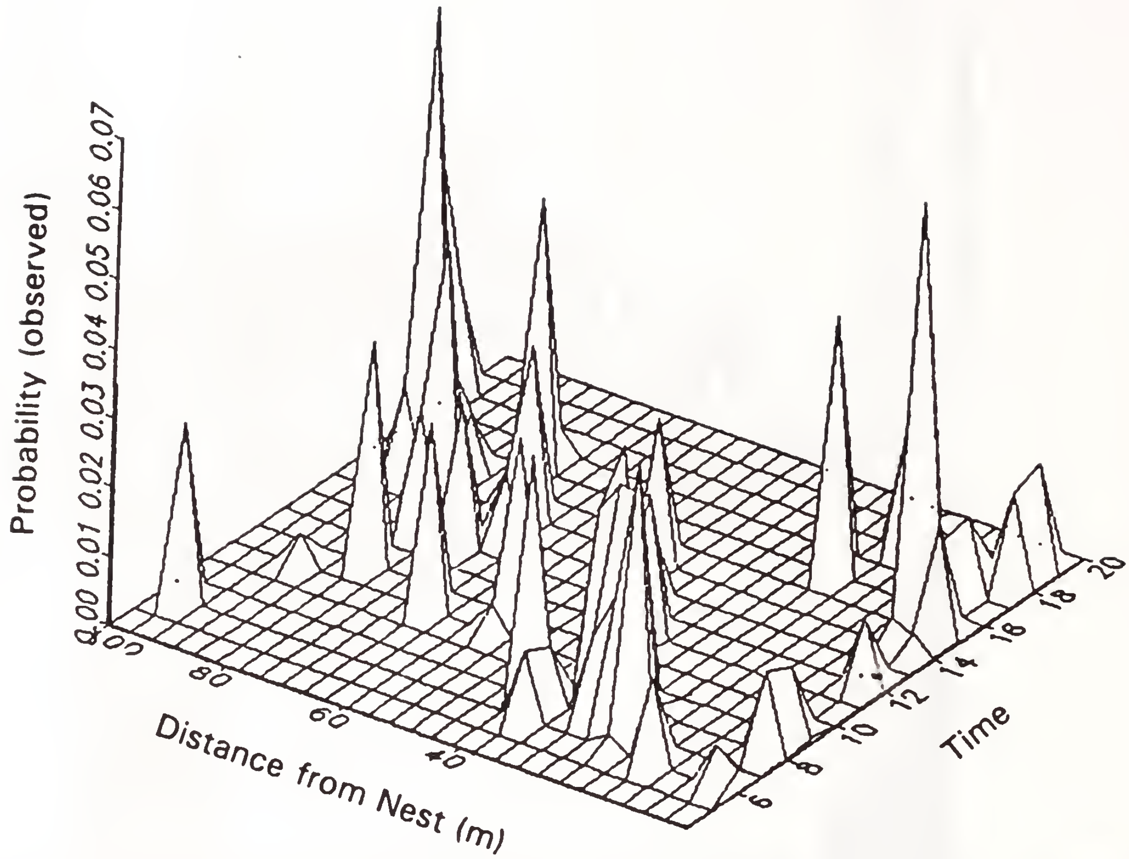

Figure 58. Probability matrix of perch distance from the active nest by hour period for 3 adult bald eagles associated with nest sites on Jackson Lake, Snake Teton, Wyoming.

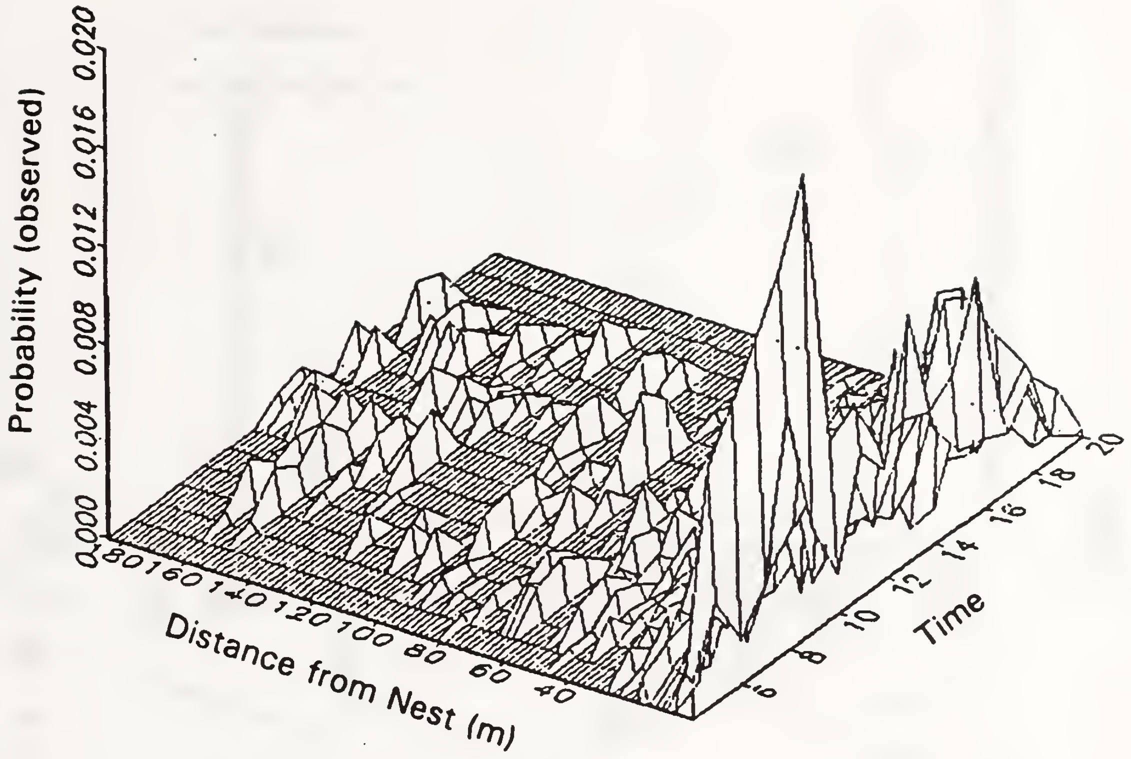

Figure 59. Probability matrix of perch distance from the active nest by hour period for 4 adult bald eagles radio-tracked in Grand Teton National Park, Snake Teton, Wyoming.

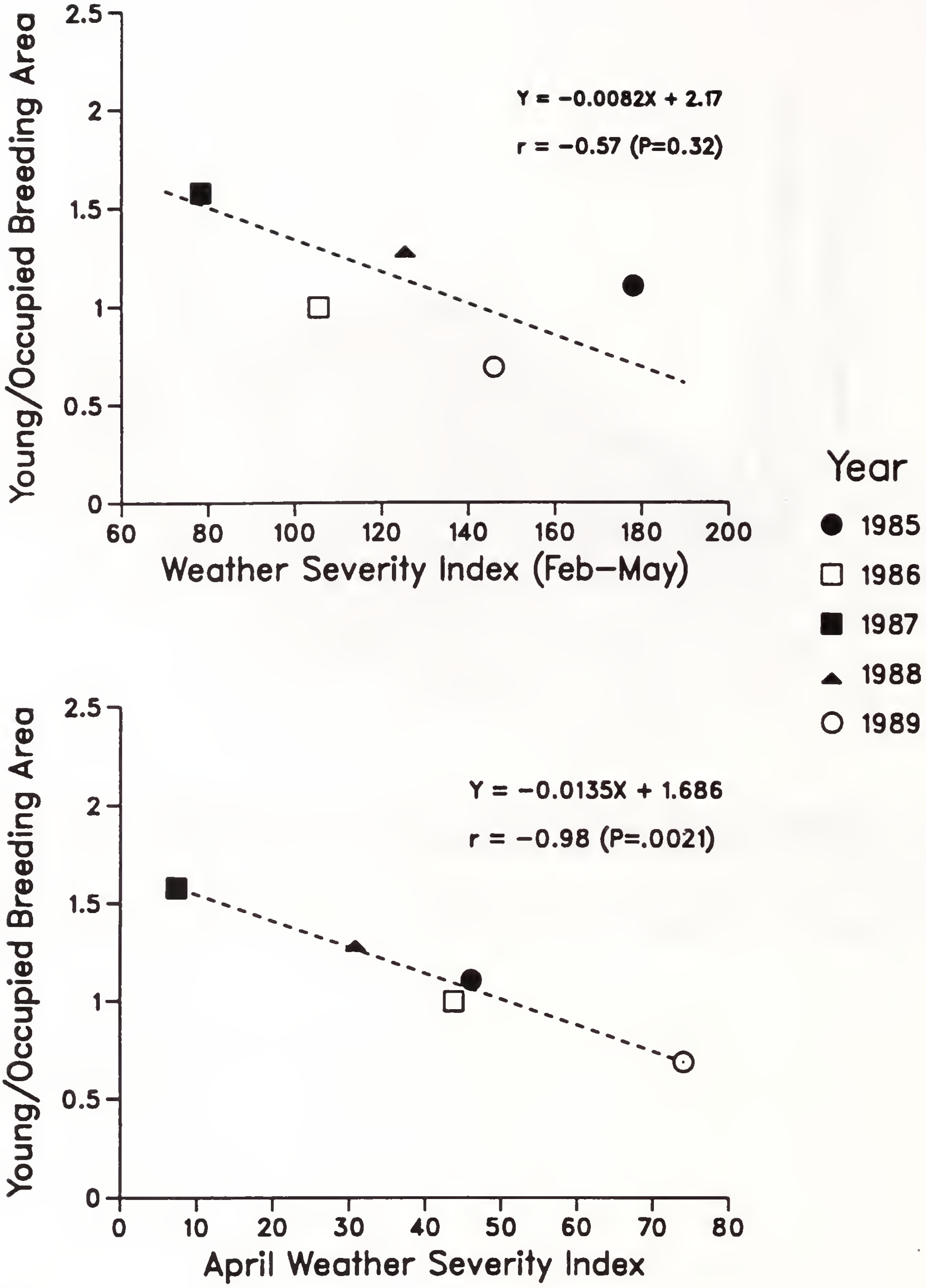

Figure 60. Regression analysis of overall bald eagle productivity with Weather Severity Index for months February - May (top) and month of April only (bottom) in the Snake Unit of Wyoming, 1985-1989.

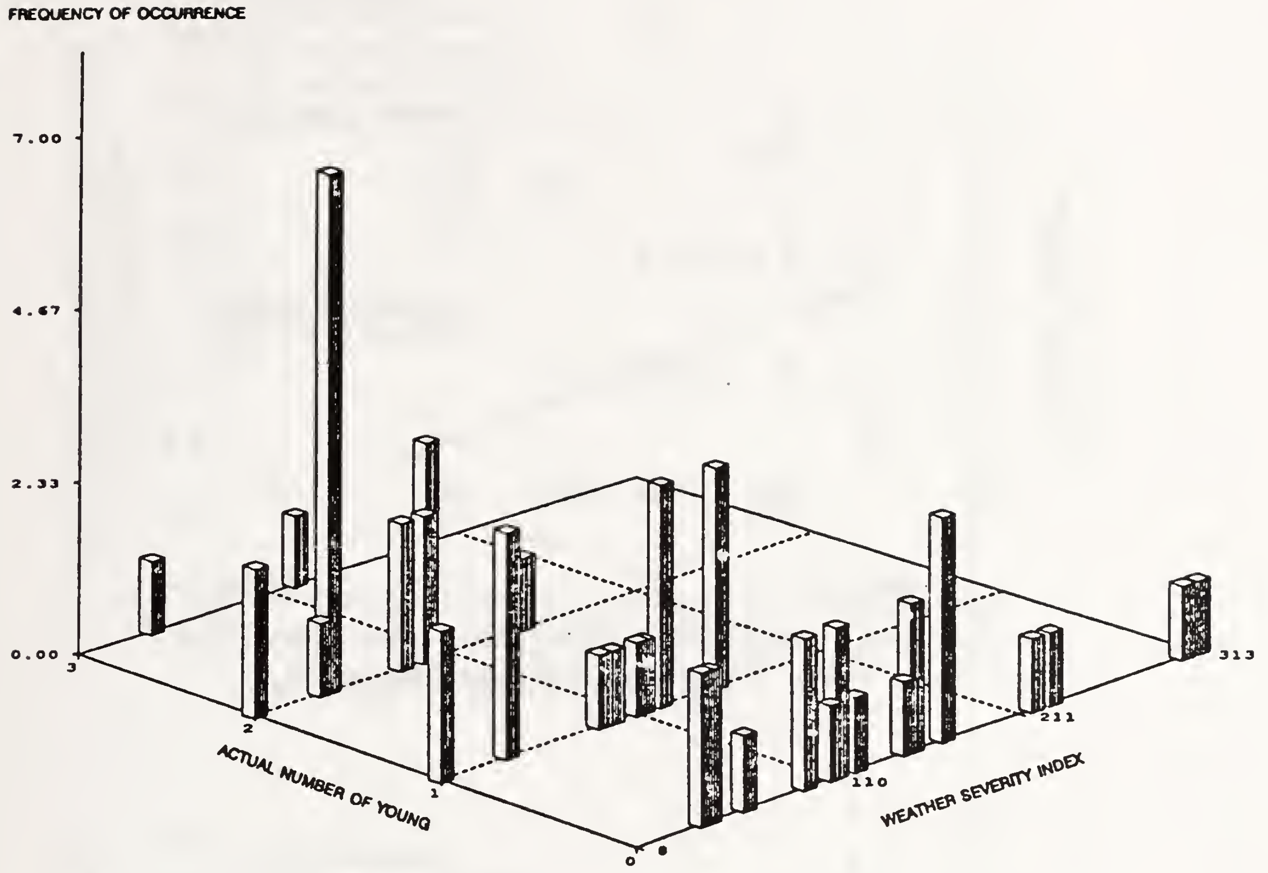

Figure 61. Frequency of occurrence of bald eagle brood sizes related to mean annual Weather Severity Index, Snake Unit of Wyoming, 1985-1989.

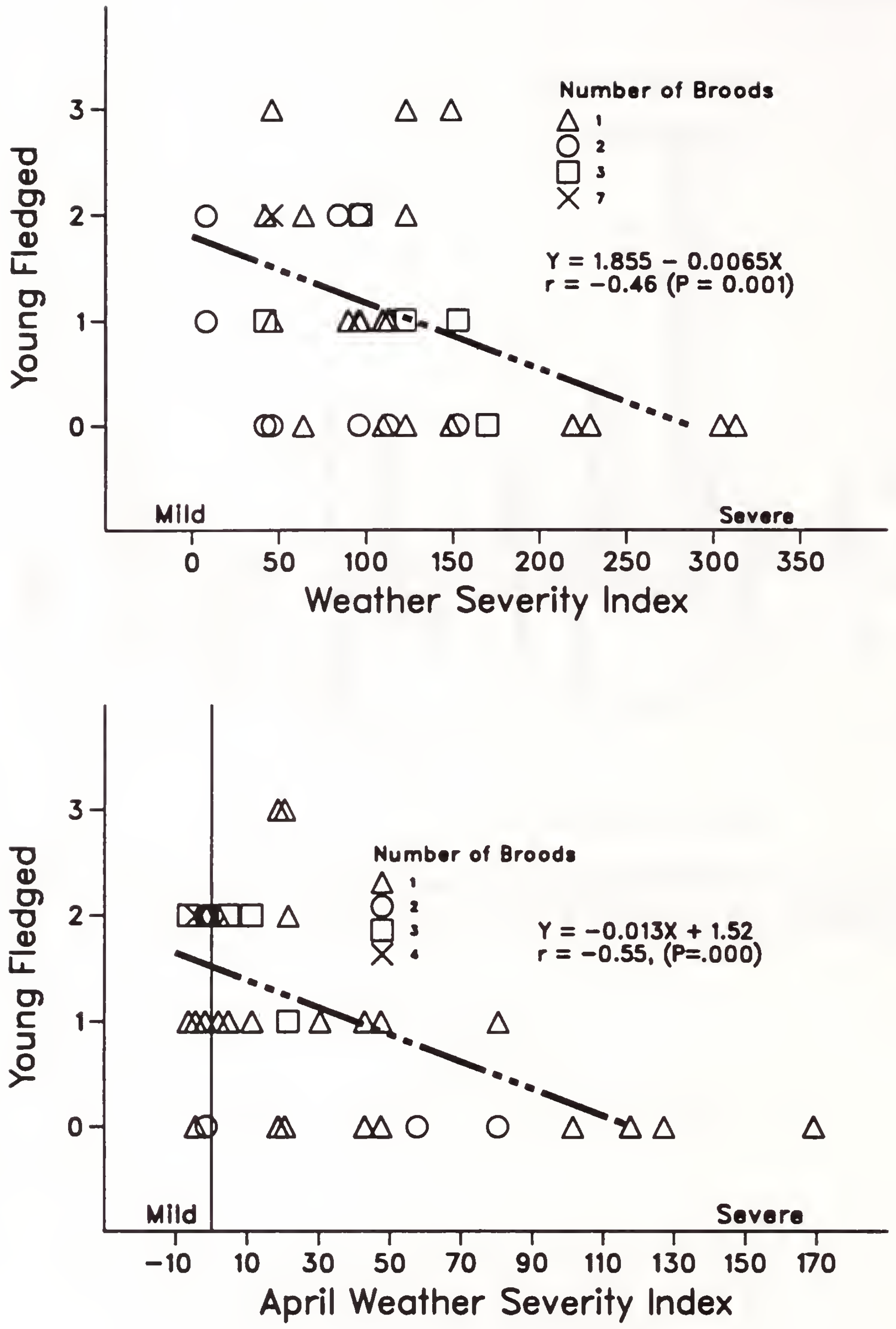

Figure 62. Relationship of Weather Severity and associated brood size of bald eagles nesting in the Snake Unit of Wyoming, Greater Yellowstone Ecosystem.

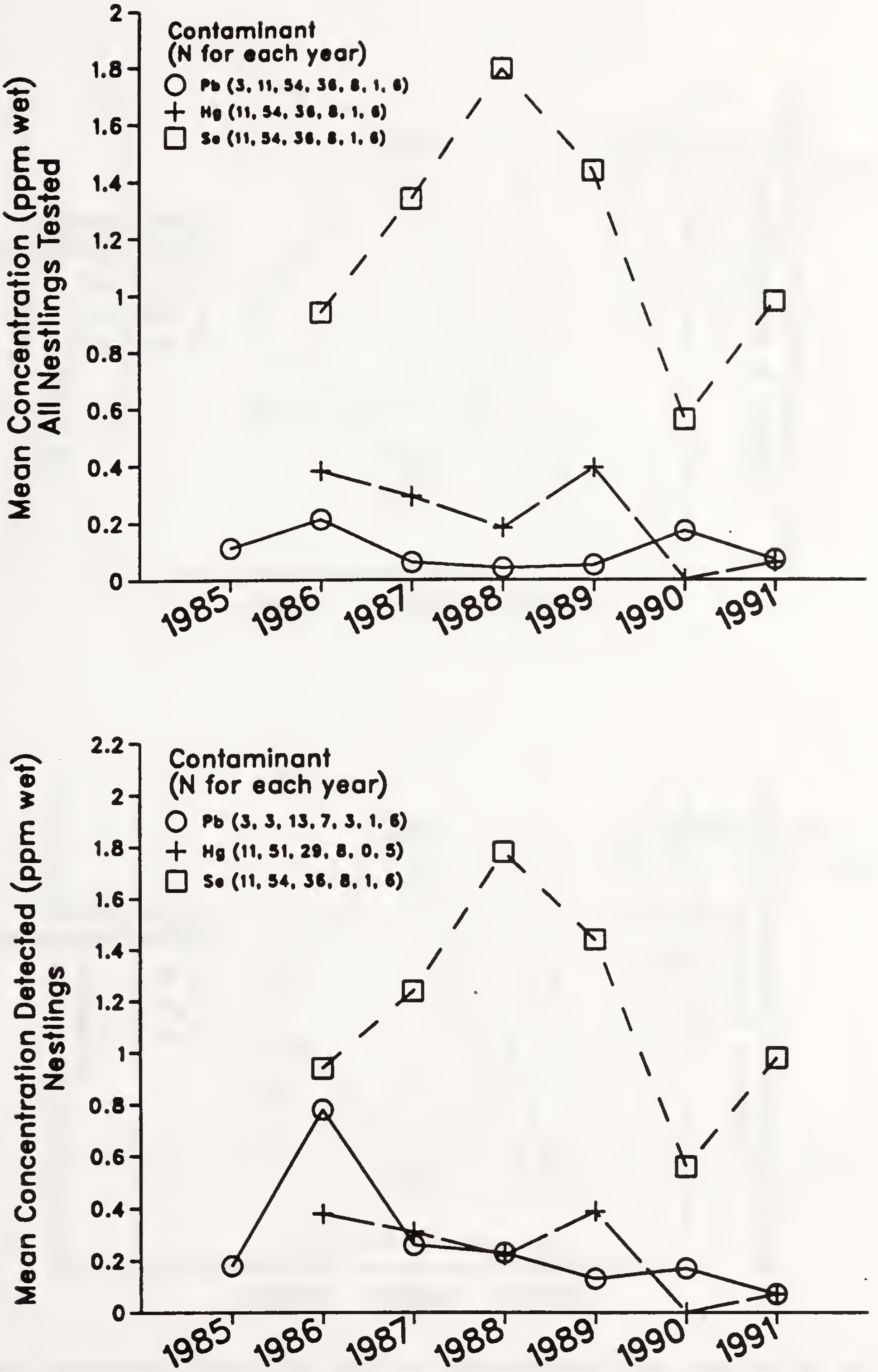

Figure 63. Mean heavy metal concentrations in blood of all nestling bald eagles in the Greater Yellowstone Ecosystem sampled (top) and only those in which respective metals were detected (bottom) by year. Detection limit ≥0.1 ppm wet weight.

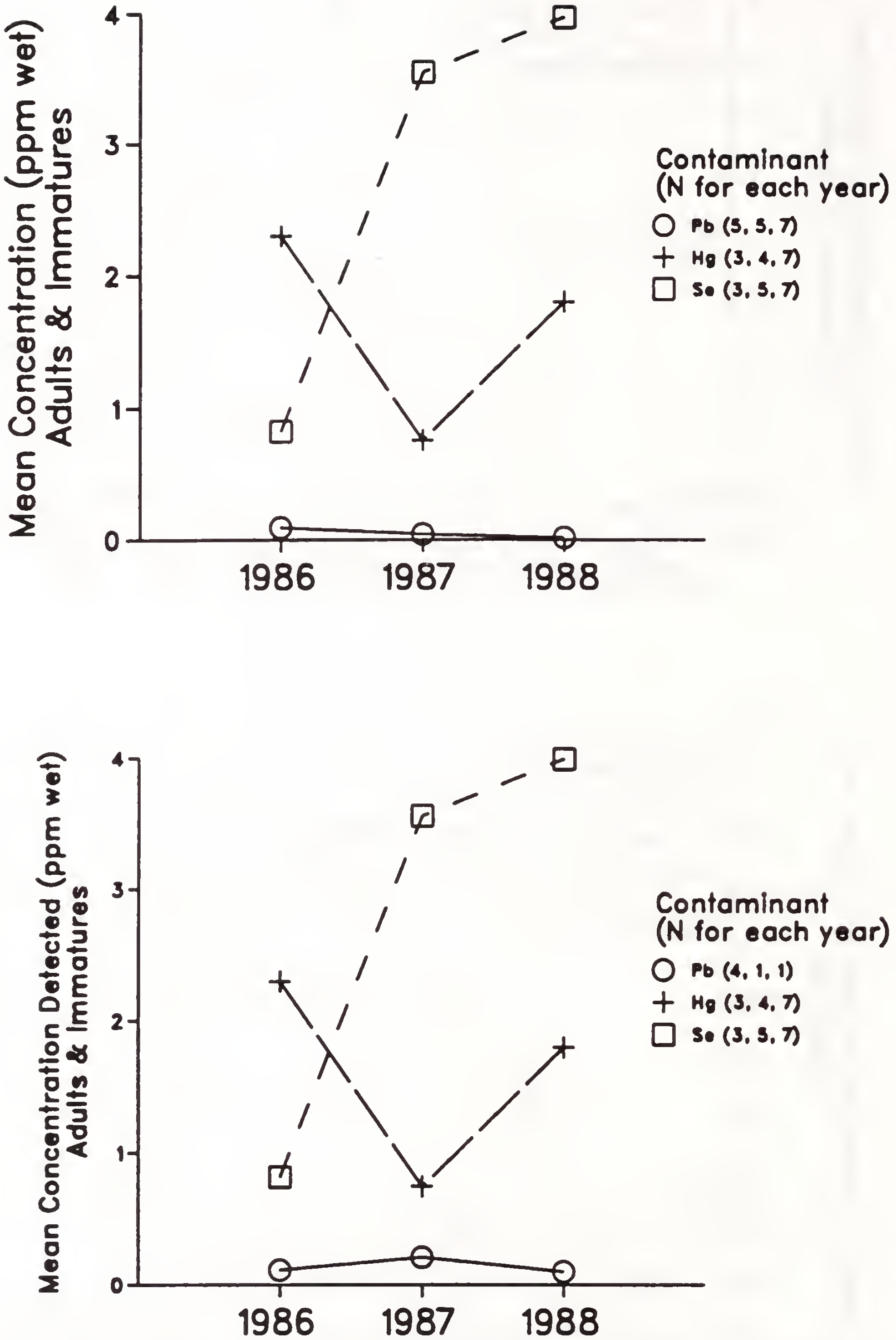

Figure 64. Mean heavy metal concentrations in blood of all resident adult and immature bald eagles in the Greater Yellowstone Ecosystem sampled (top) and only those in which respective metals were detected (bottom) by year. Detection limit ≥0.1 ppm wet weight.

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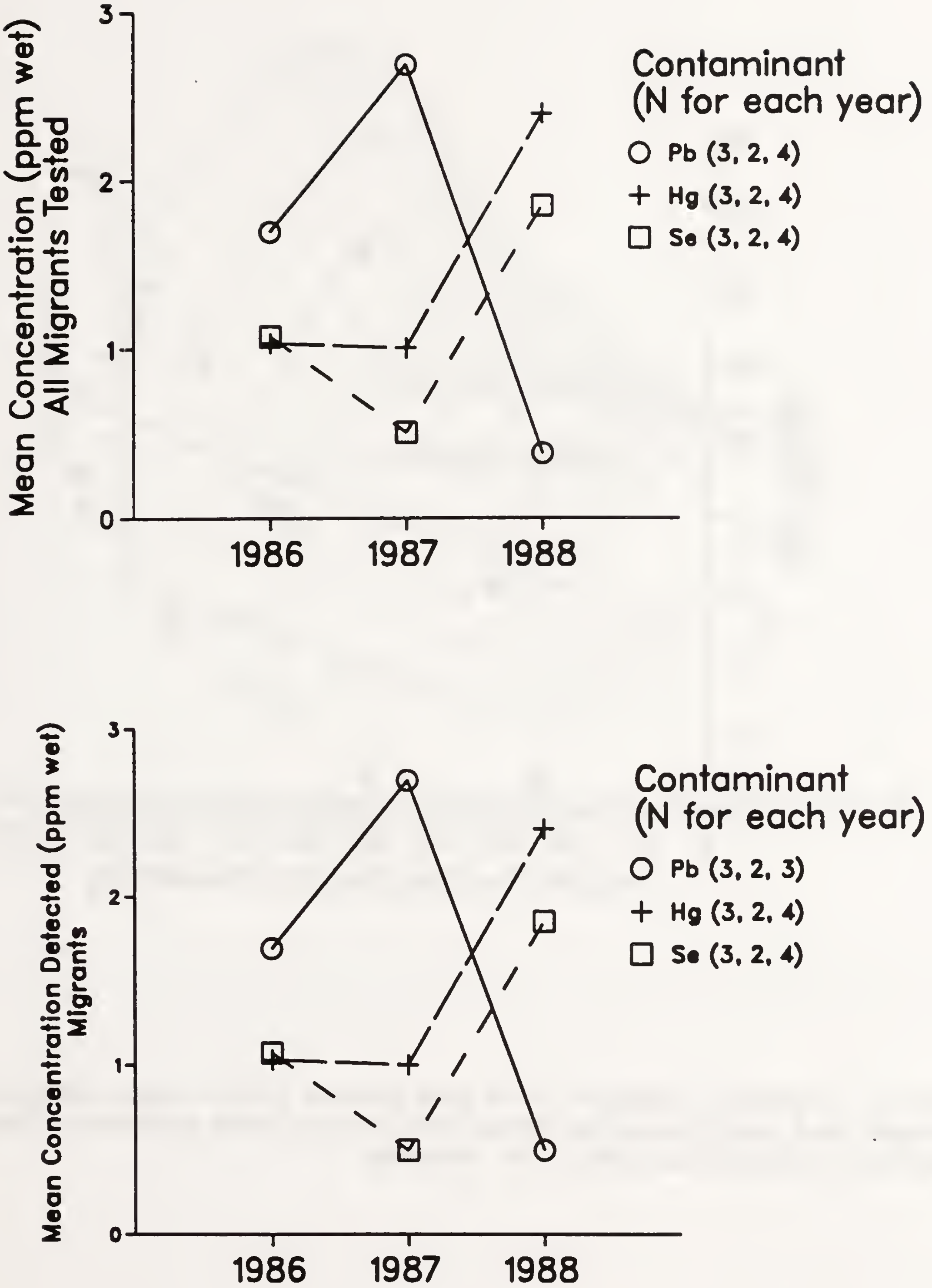

Figure 65. Mean heavy metal concentrations in blood of all migrant bald eagles in the Greater Yellowstone Ecosystem sampled (top) and only those in which respective metals were detected (bottom) by year. Detection limit ≥0.1 ppm wet weight. None were less than 4 years old.

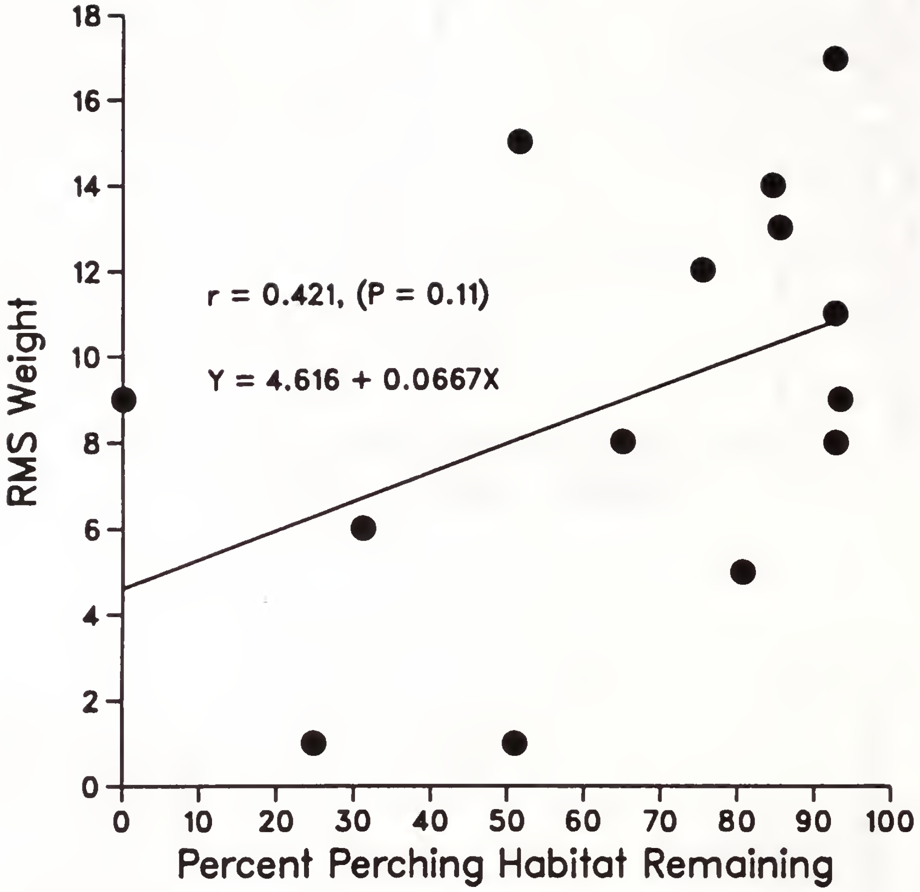

Figure 66. Regression analysis of River Mile Segment (RMS) weight (determined by Σ of bald eagle perch weights contained therein) with percent habitat remaining in South Park and Snake Teton portions of the Snake River, Wyoming.

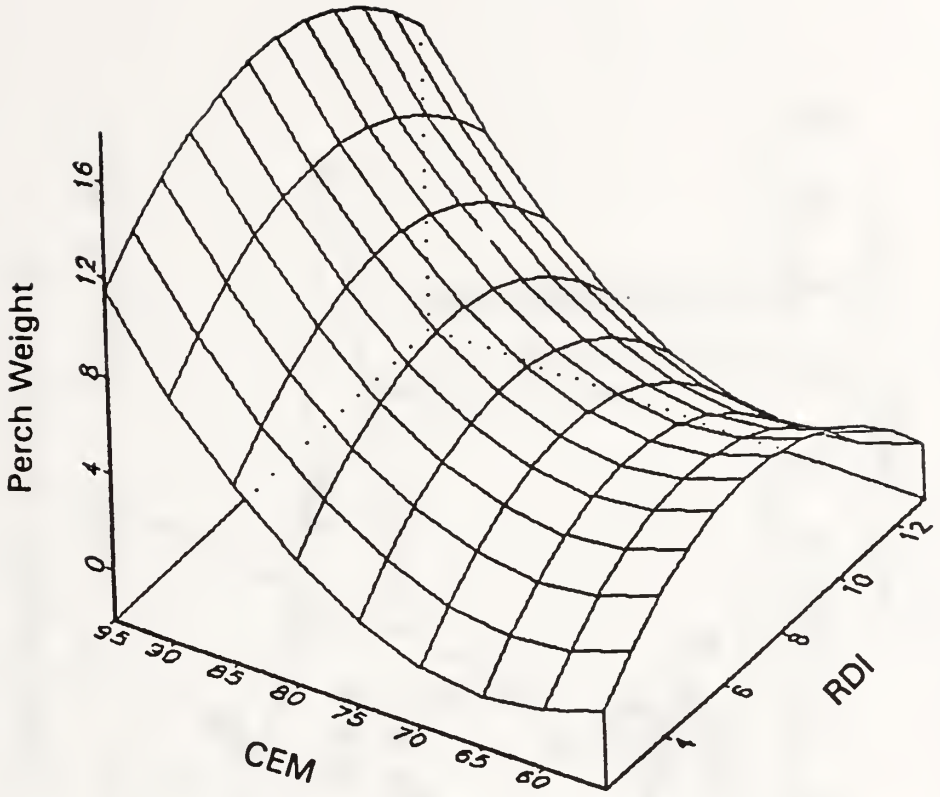

Figure 67. Relationship of perch weights of Schwabacher adult male bald eagle with time specific habitat remaining along the Snake River, Wyoming.

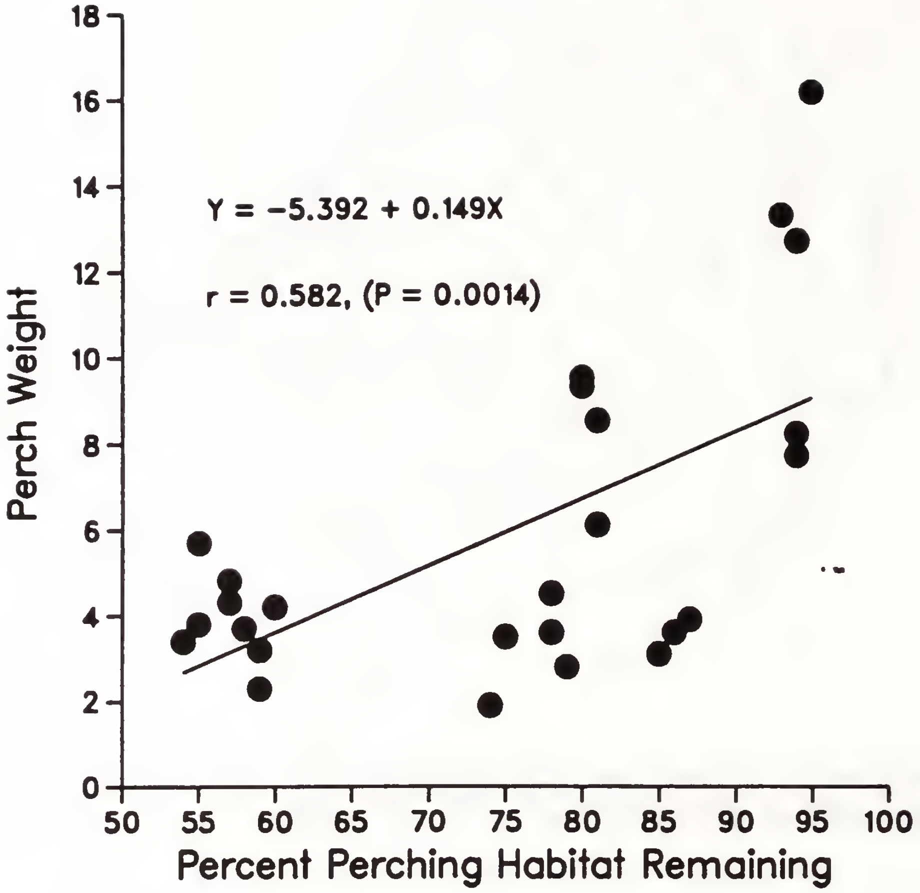

Figure 68. Regression analysis of summer perch weights of the Schwabacher adult male bald eagle with seasonal (summer) perching habitat remaining along the Snake River, Snake Teton, Wyoming.

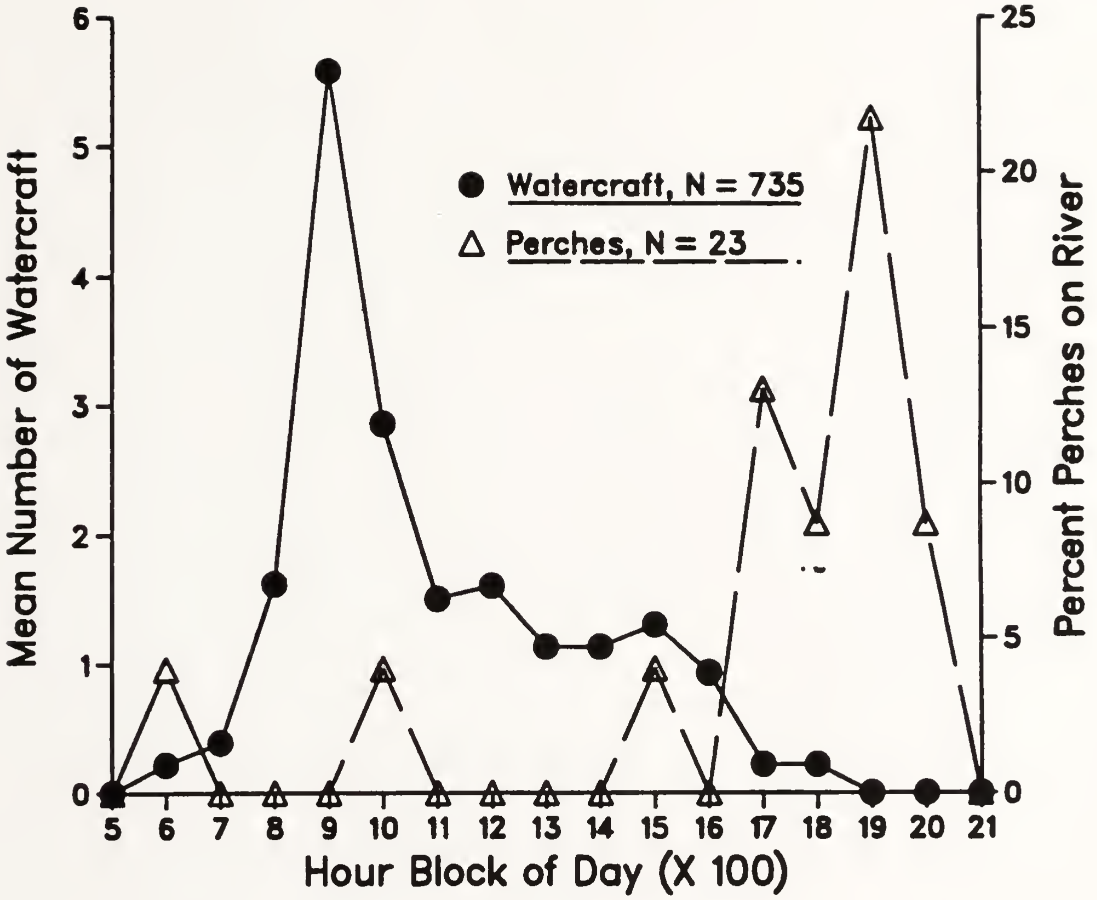

Figure 69. Percent of total perches of Cabin Creek adult male bald eagle within 10 m of the Snake River shoreline and number of watercraft on the river, per hour period. Data for perches were from 1986, watercraft from 1987.